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MONTANA STRIP MINING PERMIT APPLICATION

by

WESTERN ENERGY COMPANY

OCTOBER 15, 1973

Volume 1

Prepared for Western Energy Company
by
Westinghouse Environmental Systems Department
Box 1899
Pittsburgh, Pennsylvania 15230

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PART 1

MINING PERMIT APPLICATION

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26-2.10(10)-S10270 - APPLICATION FOR A STRIP MINING PERMIT

1. (a) Resumes of all technical and scientific personnel involved in investigations and analyses necessary for the preparation of this strip mining permit application will be found in Appendix A-1.

   (b) A description of methods and tests used to determine the required background information for this strip mining permit application will be found in Section S10300 (2) for Site Resources, Section S10340 for Topsoiling, and S10350 for Planting and Revegetation. Methods used to develop data for historic, archeologic, and socio-economic determination will be found in those specific sections.

2. MATERIALS SUBMITTED PRIOR TO PERMIT APPLICATION

Material Submitted

1. Area E Reclamation Plan
2. Area A-1 Mining Plan
3. Pit 6 Mining Plan
4. Aerial Photos Covering First Permit Year
5. Supplementary Maps for Reclamation Plans in Pit 6 and Area A-1
6. Geological Cross Sections

3. PERMIT APPLICATION FORMS

STATE OF MONTANA

DEPARTMENT OF STATE LANDS

Capitol Building
Helena, Montana 59601
Phone 406/449-2074

APPLICATION FOR SURFACE MINING PERMIT

APPLICATION NO.____________________________

Pursuant to Chapter 325, Session laws of Montana of 1973 requiring permits for mining coal, clay, phosphate, and uranium

***

NAME AND ADDRESS OF APPLICANT (Corporations or other business entity; give names and addresses of principal officers, agents, etc.)

Western Energy Company
40 East Broadway
Butte, Montana 59701
TELEPHONE NUMBER: 723-5421

NAME AND ADDRESS OF SURFACE OWNER (if different from above)

NAME AND ADDRESS OF MINERAL OWNER (if different from above)

CONTRACTORS WHO WILL BE WORKING ON PROJECT (show names, addresses, & function)

INSTRUCTIONS: See rules and regulations pursuant to the above.

LOCATION OF MINE AREA:

Sec. Twp. Rge. County

Mineral to be mined

Acres to be disturbed in next 12 months

Acres to be disturbed in life of operation

Expected date of commencement:

completion:

Estimated cost of reclamation per acre:

THIS APPLICATION MUST BE ACCOMPANIED BY:

1. Fee of $50.00.
2. Proposed mining and reclamation plans.
3. Maps (see rules and regulations).
4. Bond (see rules and regulations).
5. All materials and information required under the law and rules and regulations pursuant to it.

NOTARY:

Subscribed and sworn to before this [illegible] day of [illegible], 19__.

Notary Public for the State of Montana

Butte, Montana
Residing at

July 17, 1974
Date

I, the undersigned, hereby certify that the materials and information contained in this application are complete and are correct to the best of my knowledge and belief.

SIGNATURE OF APPLICANT

Western Energy Company

Title Vice President and General Manager

June 13, 1973
Date

Fee received

Permit issued

Application returned (Statement attached)

***The information requested on this form is attached in a separate document because of insufficient room on this form.

STATE OF MONTANA

DEPARTMENT OF STATE LANDS

APPLICATION FOR SURFACE MINING PERMIT

APPLICATION NO. ____________________

WESTERN ENERGY COMPANY, a Montana corporation having its principal office and place of business at 40 East Broadway, Butte, Montana 59701, hereby makes application for a surface mining permit pursuant to Chapter 325, Laws of Montana 1973, and submits the following information pursuant to the said Act.

1. The name and address of the applicant are: WESTERN ENERGY COMPANY, 40 East Broadway, Butte, Montana 59701. Its directors, officers and principal agents are:

Chairman of the Board ...	J. E. Corette
Vice Chairman of the Board	L. S. Stadler
President and Chief Executive	Geo. W. O'Connor
Exec. Vice President	J. A. McElwain
Vice President, Finance .	Colin W. Raff
Vice President and Treasurer	J. J. Harrington
Vice President and General Counsel	W. H. Coldiron
Vice President and Secretary	John C. Hauck
Vice President and General Manager	W. P. Schmechel
Assistant Secretaries ...	Margaret Sullivan C. J. Gilder H. L. Painter
Assistant Treasurers	J. F. Doran F. V. Woy

Directors .... J. E. Corette
Robert D. Corette
Newell Gough Jr.
J. A. McElwain
A. O. McLellan
Geo. W. O'Connor
R. H. Robinson
Clark E. Simon
Louis A. Spain
L. S. Stadler
Warren F. Vaughan
W. H. Coldiron
W. P. Schmechel.

Assistant to the
General Manager .... Martin White

Geologist .... Roger C. Rice

2. The telephone numbers of the applicant are:

Butte: (406) 723-5421
Billings: (406) 252-2277

3. The location of the mine area is in the vicinity of Colstrip, Rosebud County, Montana, as more particularly appears on the annexed maps marked Exhibit A and Exhibit B.

4. The name and address of each surface owner other than the Applicant is shown on the annexed map marked Exhibit B, except as follows: Lands marked "BN" are lands of the Burlington Northern Inc., 176 E. 5th Street, St. Paul, Minnesota 55101; lands marked "U.S.A." are lands of the United States of America, administered by the Department of the Interior, Bureau of Land Management, Federal Office Building, Billings, Montana; lands marked "State" are lands of the State of Montana administered by the Department of State Lands, Capitol, Helena, Montana; and lands marked "MPCo." are lands of The Montana Power Company, 40 East Broadway, Butte, Montana.

5. The name and address of each mineral owner other than the Applicant is shown on the annexed map marked Exhibit B; the exceptions stated in paragraph 4 hereof being applied thereto mutatis mutandis.

The Contractor who will be working on the project is Long Construction Company, 117 North 27th, Billings, Montana. This corporation will perform both mining and reclamation functions under contract with the Applicant.

6. The mineral to be mined is coal.

The acreage estimated to be disturbed during the next 12 months is 65 acres.

The acreage estimated to be disturbed during the life of the operation is 12,607, exclusive the areas on Exhibit B marked "future mining." Those areas are presently held as uncommitted reserves for which no definite time or plan of mining has been formulated.

The expected date of commencement of mining is shown for individual areas of the mining complex on the attached Exhibit A.

The expected date of completion of mining in any of the areas is uncertain and speculative, since it will be in each case contingent upon rates of take under existing and future contracts, extensions of the terms of such contracts, optional additional contract quantities and other factors impossible to assess or predict with reasonable accuracy.

The estimated cost of reclamation per acre is Seven Hundred Dollars ($700.00).

7. The sources of applicants legal right to mine on the land affected by the permit are indicated on the attached Exhibit B. For fuller identification, the leases thereon referred to are:

Legend Reference	Description
Federal Lease	Lease Billings 020989-038770 dated August 1, 1959 between the Applicant and the Bureau of Land Management; and lease Montana 073109 dated September 1, 1966 between the same parties.
BN T & M 4578	Lease between Burlington Northern Inc. and the Applicant dated July 1, 1966.
BN T & M 3982	Lease between Burlington Northern Inc. and the Applicant dated May 8, 1959 and supplement dated July 1, 1966.
State Lease	Lease between the State of Montana and the Applicant dated July 2, 1966.

In addition the Applicant has pending before the Department of the Interior, Bureau of Land Management an application for an additional 6,082.35 acres, as indicated on Exhibit B.

8. The permanent post office address of the Applicant is 40 East Broadway, Butte, Montana 59701. The Applicant has no temporary post office address.

9. Neither the Applicant nor any person associated with the Applicant holds or has held any permits under Chapter 325, Laws of Montana 1973.

10. The Applicant certifies that it is in compliance with Subsection (2) of Section 17 of the Act, and that no officer or director thereof is subject to any of the provisions of the said subsection. None of the foregoing parties or persons has ever had a strip mining license or permit issued by any other state or federal agency revoked, or has ever forfeited a strip mining bond or security deposited in lieu thereof.

I, the undersigned, hereby certify that the materials and information contained in this application and to be filed subsequent hereto, are complete and correct to the best of my knowledge and belief.

WESTERN ENERGY COMPANY

Date ____________________

By **Original Signed by W. P. Schmechel**

Vice President and General Manager

State of Montana)
: ss.
County of Silver Bow)

Subscribed and sworn to before me this 12th day of June, 1973.

(SEAL)

____

Notary Public for the State of Montana
Residing at Butte, Montana
My Commission expires July 17, 1974

4. LOCATION OF AREA TO BE MINED

The area at Colstrip, Montana, for which this strip mining permit application is being made by Western Energy Company, comprises:

Township 1 North, Range 42 East, M.P.M.
Section 18: N1/2, N1/2S1/2

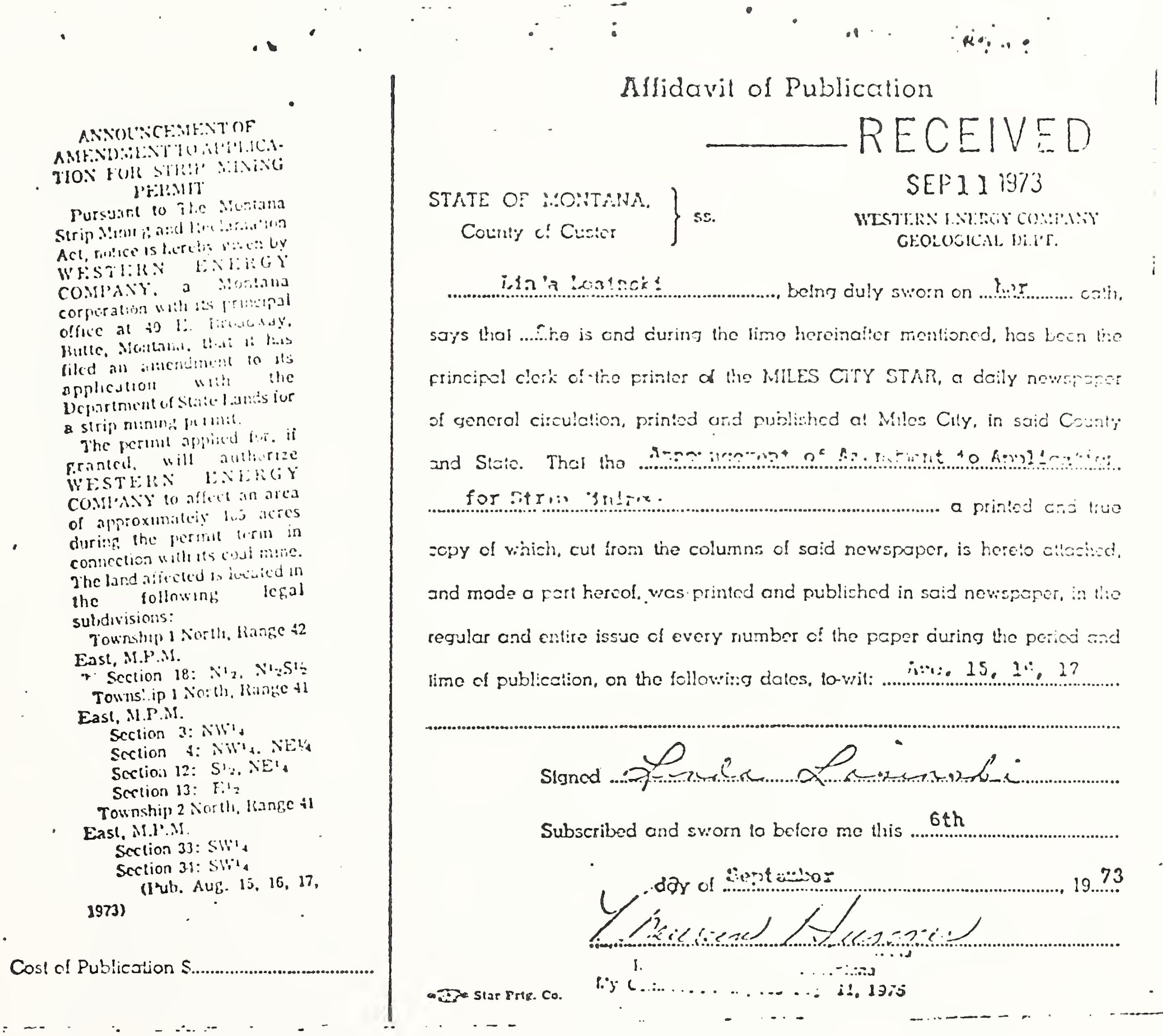
Township 1 North, Range 41 East, M.P.M.
Section 3: NW1/4
Section 4: NW1/4, NE1/4
Section 12: S1/2, NE1/4
Section 13: E1/2

Township 2 North, Range 41 East, M.P.M.
Section 33: SW1/4
Section 34: SW1/4

Western Energy Company, a wholly owned subsidiary of the Montana Power Company, became incorporated in the State of Montana in 1966. In 1968 it reactivated the Rosebud Mine, acquired from Northwestern Mining Company in 1959, at Colstrip, Montana. Through leases Western Energy Company presently controls approximately 850 million tons of recoverable, low sulfur coal reserves in the Colstrip area.

5. Section 5 is Not Applicable

6. PUBLISHED ANNOUNCEMENT



ANNOUNCEMENT OF AMENDMENT TO APPLICATION FOR STRIP MINING PERMIT

Pursuant to The Montana Strip Mining and Reclamation Act, notice is hereby given by WESTERN ENERGY COMPANY, a Montana corporation with its principal office at 40 E. Broadway, Butte, Montana, that it has filed an amendment to its application with the Department of State Lands for a strip mining permit.

The permit applied for, if granted, will authorize WESTERN ENERGY COMPANY to affect an area of approximately 165 acres during the permit term in connection with its coal mine. The land affected is located in the following legal subdivisions:

Township 1 North, Range 42 East, M.P.M.
Section 18: N½, N½S½
Township 1 North, Range 41 East, M.P.M.
Section 3: NW¼
Section 4: NW¼, NE¼
Section 12: S½, NE¼
Section 13: E½
Township 2 North, Range 41 East, M.P.M.
Section 33: SW¼
Section 34: SW¼
(Pub. Aug. 15, 16, 17, 1973)

Cost of Publication $..........

Affidavit of Publication

RECEIVED
SEP 11 1973
WESTERN ENERGY COMPANY
GEOLOGICAL DEPT.

STATE OF MONTANA, County of Custer } ss.

Linda Losinski, being duly sworn on her oath, says that she is and during the time hereinafter mentioned, has been the principal clerk of the printer of the MILES CITY STAR, a daily newspaper of general circulation, printed and published at Miles City, in said County and State. That the Announcement of Amendment to Application for Strip Mining. a printed and true copy of which, cut from the columns of said newspaper, is hereto attached, and made a part hereof, was printed and published in said newspaper, in the regular and entire issue of every number of the paper during the period and time of publication, on the following dates, to-wit: Aug. 15, 16, 17

Signed Linda Losinski

Subscribed and sworn to before me this 6th day of September, 1973

My C[illegible] 11, 1975

Star Prtg. Co.

7. Section 7 is Not Applicable.

8. MAP CERTIFICATIONS

2602.10(10) - S10280 - PROSPECTING

(This Section is Not Applicable.)

LEASE HISTORY

The lease deeds of record that vest the Colstrip coal minerals to Western Energy Company areas follows:

Date	Leased From
6-1-59	Northern Pacific R.R. (Burlington Northern)
6-1-59	United States America
6-1-66(supplemental to 6-1-59)	Northern Pacific R.R. (Burlington Northern)
6-1-66	Northern Pacific R.R. (Burlington Northern)
6-2-66	State of Montana
9-1-66	United States of America
12-11-68	State of Montana
6-3-70	State of Montana
6-3-70	State of Montana

OWNERSHIP OF LANDS WITHIN 1/2 MILE

Township 2 North Range 41 East

Section:		
	28	SW1/4 - Helgerson - Spokane, Washington N1/2;SE1/4 - Montana Power Co.
	29	S1/4 - Malcolm Philbrick - Forsyth, Montana N3/4 - Burlington Northern
	30	D. McDonald - Colstrip, Montana
	31	Burlington Northern
	32	Burlington Northern
	33	Burlington Northern
	34	Montana Power Co.
	35	Burlington Northern
	36	State of Montana

Township 1 North Range 41 East

Section:	1		Burlington Northern
	2		Burlington Northern
	3		Burlington Northern
	4	E1/2	Western Energy Company
		W1/2	Burlington Northern
	5		Burlington Northern
	6	S1/2	Farley, Inc., Forsyth, Montana
	8	478 Ac	Greenleaf Land & Livestock, Forsyth, Montana
	8	162 Ac	Farley, Inc., Forsyth, Montana
	9		Burlington Northern
	10		Burlington Northern
	11		Burlington Northern
	12		Burlington Northern
	13		Burlington Northern
	14	N1/2	United States of America
	24		James & Merle Snider, Forsyth, Montana

Township 1 North Range 42 East

Section:	6	SW1/4SW1/4	Burlington Northern
		Remainder	M & J.W. Egan, Forsyth, Montana
	7		Burlington Northern
	8		Burlington Northern
	17		Burlington Northern
	18	N3/4	Burlington Northern
		S1/4	W. Dean, Forsyth, Montana
	19	N1/4	Burlington Northern
	20	N1/2	John Sufficoal - Colfax, Iowa

(a) ARCHAEOLOGICAL, HISTORICAL, ETHNOLOGICAL AND CULTURAL VALUES

No historic monuments or natural landmarks of note are located within the boundaries of lands controlled by Western Energy Company.

In 1971, Western Energy Company contracted with the University of Montana and in 1973 with the Montana College of Mineral Science and Technology Foundation to conduct a detailed archeological survey on all leased or owned land so that any finds could be excavated, recorded and preserved before their possible destruction during the surface mining process. A number of archeological sites were found which provide information on the way of life of the Plains Indians of this area. These sites include examples of Indian rock art, rock shelters and lookout sites, as well as one bison kill location. (1,2) Figure 1 shows the location of these sites.(3).

The occupation site falling in Area A-1, shown in Figure 1, was investigated during the detailed survey, and it does not fall into the area to be mined in 1974. Should future operations indicate that this site will be disturbed and if a more detailed investigation is deemed necessary at that time, Western Energy will assume responsibility for all reasonable excavations by professionals as far in advance of the disturbance as is practicable.

REFERENCES

1. Fredlund, Dale E., 1971 Archaeological Survey, Western Energy Company Lands, Rosebud County, Montana, May 17, 1971.

2. Fredlund, Dale E., A Summary of Archaeology in Montana for Westinghouse Environmental systems, March 1973.

3. Section 2.2.2.12, Historic and Natural Values.

(b) GEOLOGICAL FORMATIONS

There are no significant or unique geological formations in the area for which the 1974 strip mining permit has been applied. Some sedimentary (sandstone) bluffs are in the area to be mined, however; they could not be considered unique scenic formations since they are ubiquitous in this part of Montana.

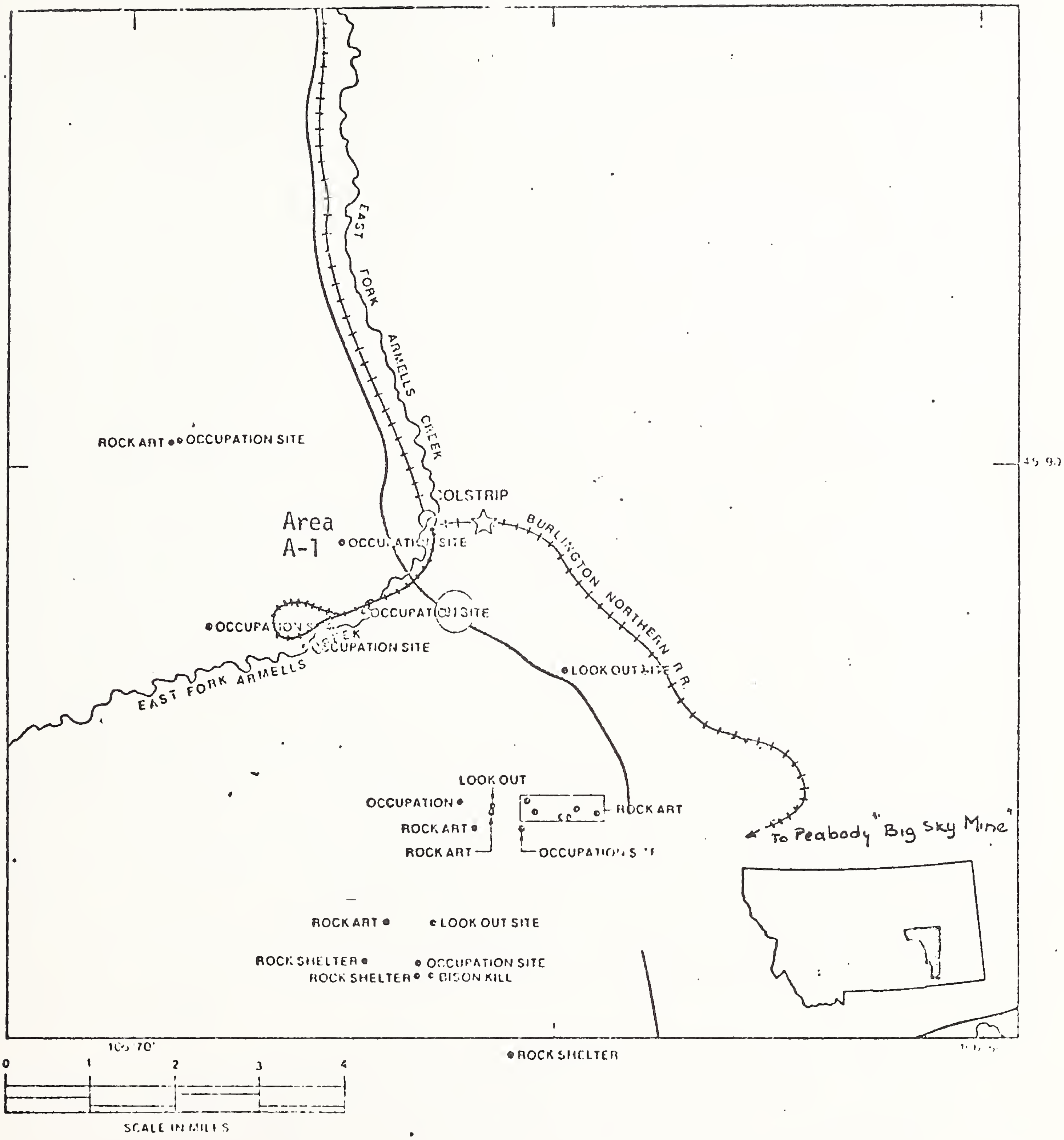

EAST FORK ARMELLS CREEK
ROCK ART
OCCUPATION SITE
COLSTRIP
Area A-1
OCCUPATION SITE
BURLINGTON NORTHERN R.R.
OCCUPATION SITE
OCCUPATION SITE
CREEK
OCCUPATION SITE
EAST FORK ARMELLS
LOOK OUT SITE
LOOK OUT
OCCUPATION
ROCK ART
ROCK ART
ROCK ART
OCCUPATION SITE
To Peabody "Big Sky Mine"
ROCK ART
LOOK OUT SITE
ROCK SHELTER
OCCUPATION SITE
ROCK SHELTER
BISON KILL
ROCK SHELTER
0
1
2
3
4
SCALE IN MILES

Figure 1 ARCHAEOLOGICAL AND HISTORICAL SITES IN THE COLSTRIP AREA

(c) AREA DESCRIPTION

Lands to which the 1974 strip mining permit application applies are representative of the southeastern region of Montana in both floral and faunal composition. The mixed grasslands-pine woodlands exhibit an ecological similarity throughout an area of relatively uniform climate and parent soil material. Once the grasslands supported herds of buffalo, which have been replaced by cattle. Severe overgrazing of some areas in the past has resulted in retrogressive succession. Aside from the replacement of the buffalo by cattle, animal life in the area is relatively unchanged. A portion of the grasslands around Colstrip has been converted to agricultural use. These agronomic area comprise planted and fallow fields with an emphasis on grain and hay crops. Strip mining has consumed other portions of the grasslands and these are being returned to grazing uses through reclamation.
Strip mining conducted 1924-1958 by the Northern Pacific Railway Co. consumed other portions of the grasslands. However, these, too, are being reclaimed and will be restored to grazing purposes under a program begun in 1971 by Burlington Northern, Inc.

Since 1968, before Western Energy first began large scale operations of the Rosebud Mine acquired from Northwestern Improvement Company, Western Energy Company contracted with and has vigorously supported efforts of the Montana Agricultural Experiment Station to research and determine the best reclamation practices to follow in the Colstrip area. The specific goals of Western Energy in this program are to reclaim all mining areas disturbed in its operations and to expedite the restoration process with as little disturbance to the local ecology as possible.

This process involves creating surface depressions on shaped spoils with the intent of preventing erosion and capturing available moisture. Systems of surface manipulation include deep chiseling, gouging, offset-listering and dozer basins. Each has specific applications under which it is effective in erosion prevention and moisture retention. The final result is hardier stands of vegetation and permanent erosion control.

As in the past, future operations of Western Energy Company will be in compliance with existing state and federal environmental, health and safety regulations.

(b) GEOLOGICAL FORMATIONS

There are no significant or unique geological formations in the area for which the 1974 strip mining permit has been applied. Some sedimentary (sandstone) bluffs are in the area to be mined, however, they could not be considered unique scenic formations since they are ubiquitous in this part of Montana.

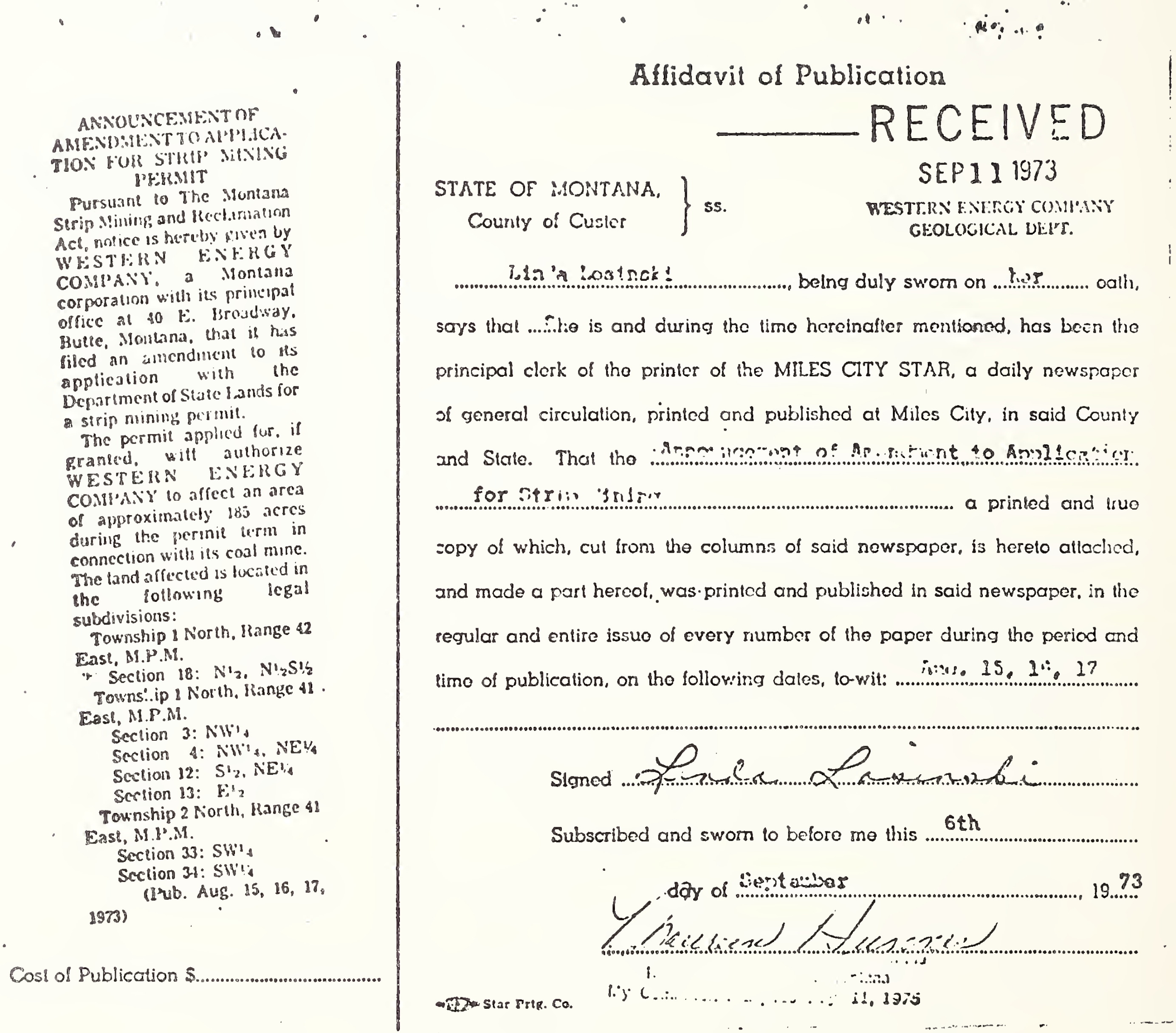
(c) AREA DESCRIPTION

Lands to which the 1974 strip mining permit application applies are representative of the southeastern region of Montana in both floral and faunal composition. The mixed grasslands-pine woodlands exhibit an ecological similarity throughout an area of relatively uniform climate and parent soil material. Once the grasslands supported herds of buffalo, which have been replaced by cattle. Severe overgrazing of some areas in the past has resulted in retrogressive succession. Aside from the replacement of the buffalo by cattle, animal life in the area is relatively unchanged. A portion of the grasslands around Colstrip has been converted to agricultural use. These agronomic areas comprise planted and fallow fields with an emphasis on grain and hay crops. Strip mining has consumed other portions of the grasslands.

Mining practices of the past have done little to return the older mined areas to natural vegetation. On mine spoils, dating from 1921 to 1959, the vegetation is irregular and sparse, limiting the faunal life present. However, since 1968, before Western Energy first began large scale operations of the Rosebud Mine acquired from Northwestern Mining Company, Western Energy Company contracted with and has vigorously supported efforts of the Montana Agricultural Experiment Station to research and determine the best reclamation practices to follow in the Colstrip area. The specific goals of Western Energy in this program are to reclaim the older spoils areas and to use progressive mining methodswhich will allow the safe removal of nationally needed low sulfur coal and at the same time expedite the restoration of newly mined areas with as little disturbance to the local ecology as possible. In many cases, it has been found through experimentation, proper restoration will improve the moisture retention characteristics of the terrain to result in hardier stands of vegetation. As in the past, future operations of Western Energy Company will be in compliance with existing state and Federal environmental, health and safety regulations.

5. Section 5 is Not Applicable

6. PUBLISHED ANNOUNCEMENT



ANNOUNCEMENT OF AMENDMENT TO APPLICATION FOR STRIP MINING PERMIT

Pursuant to The Montana Strip Mining and Reclamation Act, notice is hereby given by WESTERN ENERGY COMPANY, a Montana corporation with its principal office at 40 E. Broadway, Butte, Montana, that it has filed an amendment to its application with the Department of State Lands for a strip mining permit.

The permit applied for, if granted, will authorize WESTERN ENERGY COMPANY to affect an area of approximately 185 acres during the permit term in connection with its coal mine. The land affected is located in the following legal subdivisions:

Township 1 North, Range 42 East, M.P.M.
Section 18: N½, N½S½
Township 1 North, Range 41 East, M.P.M.
Section 3: NW¼
Section 4: NW¼, NE¼
Section 12: S½, NE¼
Section 13: E½
Township 2 North, Range 41 East, M.P.M.
Section 33: SW¼
Section 34: SW¼
(Pub. Aug. 15, 16, 17, 1973)

Cost of Publication $..................................

Affidavit of Publication

RECEIVED
SEP 11 1973
WESTERN ENERGY COMPANY
GEOLOGICAL DEPT.

STATE OF MONTANA, } ss.
County of Custer }

Linda Losinski, being duly sworn on her oath, says that She is and during the time hereinafter mentioned, has been the principal clerk of the printer of the MILES CITY STAR, a daily newspaper of general circulation, printed and published at Miles City, in said County and State. That the Announcement of Amendment to Application for Strip Mining a printed and true copy of which, cut from the columns of said newspaper, is hereto attached, and made a part hereof, was printed and published in said newspaper, in the regular and entire issue of every number of the paper during the period and time of publication, on the following dates, to-wit: Aug. 15, 16, 17

Signed Linda Losinski

Subscribed and sworn to before me this 6th day of September, 1973

[illegible]
My C[illegible] 11, 1975

Star Prtg. Co.

7. Section 7 is Not Applicable.

8. MAP CERTIFICATIONS

I, the undersigned, hereby certify that the maps submitted with Western Energy Company's Application for Surface Mining Permit, Chapter 325 SLM 1973 are correct, and shows to the best of my knowledge and belief all the information required by the strip mining laws of this state.

Roger C. Rice

Montana Professional Engineer
No. 1112E

STATE OF MONTANA)
: ss.
COUNTY OF SILVER BOW)

On this 18th day of October, 1973, before me, a Notary Public for the State of Montana, personally appeared Roger C. Rice known to me to be the person whose name is subscribed to the above instrument and acknowledged to me that he executed the same.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my Notarial Seal the day and year first above written.

SEAL

Notary Public for the State of Montana
Residing at Butte, Montana
My Commission expires: [illegible]

2602.10(10) - S10280 - PROSPECTING

(This Section is Not Applicable.)

26-2.10(10) - S10290 - DEFINITIONS

Western Energy Company accepts the definitions of access roads, haulageway roads, ramp roads, and soil horizons as given in 26.2.10(10) - S10290 of the Adopted Rules and Regulations Pursuant to Chapter 325, Session Laws of Montana, 1973, and these terms will be used in the accepted denotation throughout this permit application.

26-2.10(10)-S10300 PREPLANNING

1. (a) MINING PLAN

1. (a)(1) Area A-1

Mining in area A-1 will be accomplished with a dragline extended bench method and a spiral pit layout as per attached exhibits. The plan is to circumscribe the area with a boxcut. The initial cut advances into deeper overburden until available stripping capacity to meet coal production requirements has been exceeded. The dragline used for stripping must then deadhead back to an area of less overburden, etc., until the peripheral boxcut is completed. Boxcut spoils will be out-cast from the area except where enough spoil room is not provided due to highways, railroads, or future adjacent mining areas with 75 feet or less overburden. In such cases, boxcut spoils will be cast into the area to be mined and rehandled on a future pass as mining advances toward the center of the area. Final grading with dozers of the outside half of out-cast spoils will be concurrent with the mining at a 5:1 slope. Grading of in-cast spoils will be accomplished after rehandle, as the passes upon which they are placed are mined. In the spiral pit layout with a perimeter boxcut, as proposed, mining advances toward the center of the pit, thus eliminating the typical final cut highwall with its inherent reclamation problems. The final void formed in the center will be filled and landscaped with dozers. With this mining system **possible** haulage way roads will be located on areas to be mined with ramps entering the pit from the contained highwall side, thus eliminating traffic and ramp roads through the spoils that otherwise cause delayed reclamation on areas adjacent to spoils-side ramp roads. All spoils-side ramp roads will be at a 7% grade or steeper.

The initial perimeter boxcut will provide for the impoundment and control of water and prevent it from entering the mining area from outside. Thus only that precipitation falling on the island within the boxcut perimeter must be diverted with interceptor dams. Interceptor dams will be constructed and maintained as required to minimize collection of surface water in the pit. Water which may result from direct rainfall or subsurface seepage will be collected in pit sumps as required as mining advances. Water quality will be tested at these locations prior to discharge as irrigation onto reclaimed lands or into natural drainage systems from the mining area. Testing of water in the pit sumps in accordance with State and Federal regulations will determine the necessity for water treatment facilities prior to discharge into natural drainage. Areas for settling ponds and other such facilities will be designated. From experience in the Pit Six Area and in old boxcuts filled with water, no acid water problems are anticipated and settling of sediment will occur in the pit sumps.

1. (a)(2) Pit 6

The mining plan for Pit 6 is to continue the use of the present equipment in the combined stripping method which has proven its potential for successful reclamation in the past. The present equipment consists of 1 Bucyrus-Erie Model 1050-B stripping shovel equipped with a 24 cu. yd. bucket, 1 Marion Model 360-M dragline equipped with an 8 cu. yd. bucket, 3-wheel-tractor scrapers, several bulldozers and 1 rubber tire front end loader. The present mine layout will continue to the economic stripping limits or erosional edge of the Rosebud seam as indicated in the exhibits. Exit from Pit 6 will then be made through a boxcut extension, to Area E-1 where mining can resume. This will develop approximately 1,000,000 tons additional reserves.

In general, the stripping sequence is as follows:

1. Scrapers will remove topsoil from the mining area either to stockpiles for final replacement later or directly to graded spoil areas previously mined.

2. Scrapers will also move sandy subsoil material onto areas where final grading is taking place.

3. Bulldozers will push approximately one-third of the exposed burden into the pit left from the previous pass where coal has been removed.

4. Scrapers will additionally move overburden directly to the spoils valley left by the 1050-B shovel on the previous pass and onto haul ramps to effect a continual backfilling process and maintain their grade at 7 percent minimum.

5. The 1050-B shovel will cast the remaining overburden onto the dozer spoils, part of which is rehandled with a rubber tire front-end loader into the spoils valley of the present 1050-B pass.

The 360-M dragline will work independently to complete a partial boxcut around the pit limit, outcasting its spoils for use later by dozers to reduce the final highwall to a 3:1 slope. The 360-M will then open the exit boxcut to Area E-1.

1. (a)(3) Area E

In Area E, Western Energy intends to improve the efficiency of the 1050-B shovel by making a narrower pass and working it against a constant 63-foot highwall,the unassisted digging limit of the 1050-B shovel, using the following stripping sequence:

1. Scrapers will remove topsoil, sandy subsoil material, and overburden over 90 feet above the coal, by removing a bench cut one pass ahead of the 1050-B shovel to areas required to keep topsoiling, subsoiling, and final grading concurrent.

2. The overburden from 63 feet to 90 feet above the coal, not already removed by the scrapers, will be dozed into the pit. This material will be rehandled by the 360-M dragline working from the previous 1050-B spoil bank to a final grading area. The dozer and dragline will work independently of the 1050-B shovel.

   Utilization of a large dragline in the near future would eliminate the need for scrapers to remove overburden.

3. The 1050-B shovel will remove the remaining 63 feet of overburden over the coal to uncover 3 million tons per year.

Existing interceptor ditches will be used to divert surface runoff from entering the mining area. Water which may result from direct rainfall or sub-surface seepage will be collected in pit sumps, as required, as mining advances. This water will be tested at these locations prior to discharge as irrigation onto reclaimed lands or into natural drainage systems from the mining area. It is not anticipated that any such facilities will be needed, however. From experience in the Pit 6 area and old boxcuts filled with water, no acid water problems are anticipated and settling of sediment will occur in the pit sumps.

Cross sections showing the grading and backfilling of the highwall areas in Pit 6 have been submitted prior to this report.

I. (b) RECLAMATION PLAN

In general, grading and backfilling will not be more than two spoil ridges outside the pit being worked, except in areas of extreme overburden, haulage ramps, and boxcuts; which will be handled as shown on the mining plan drawings. After enough area has been mined to permit the grading at a 5:1 slope of the inside half of boxcut spoils around the perimeter of the mining area, Western Energy's intent is to keep the final grading, subsoiling, and topsoiling operations concurrent with the stripping.

In Area A-1, a 60-yard dragline located half way up the spoils on an extended bench will be used. The dragline position allows enough reach whereby it can cast the spoils without making the typical spoils ridge and it will leave the spoils in a level, semi-graded condition . It will transfer a mantle of sandy subsoil on top, to be finally graded with dozers, and transfer topsoil into windrows on top of the spoils of the previous pass. As the dragline advances this will be spread by dozers onto the spoils of the present pass, surface manipulated, and planted in season. Scrapers would thus be used only to strip the topsoil in front of the drilling and blasting operations and transport it to stockpiles at intervals. These areas will be leveled to receive the stockpiles. The transfer across the pit accomplished by the dragline, will eliminate the need for frequent ramps down the highwall and up the spoils. This will provide for economic transfer of topsoil and almost immediate reclamation with a minimum of disturbed area to be reclaimed.

1. (c) SCHEDULE

Backfilling and grading of the disturbed area will be completed prior to removal of the necessary reclamation equipment from the area of operation. Weather permitting all backfilling and grading will be completed within 90 after it has been determined that the operation is completed or that a prolonged suspension of work in the area will occur. Final pit reclamation will proceed as close behind the coal loading operation as the frequency and location of ramp roads, the use of overburden stripping equipment in highwall reclamation, and other factors may allow.

2. SITE RESOURCES INVENTORIES

2. (a) SOIL SURVEY

In this report major emphasis is placed on the various soils that were mapped and the interpretation of the results for stockpiling purposes, to be used in maintaining adequate cover growth after mining operations have ceased.

The legend for each soil series are shown in Exhibit 1 with the corresponding map sympol. The description of each horizon of all series is given separately.

Soil survey includes three areas; Pit No. 6, Area E, and A 1. Since soils from these three areas lap over, each series will be grouped together for interpretation.

Purpose and Methods of Soil Survey

This survey was done by soil scientists to identify the types of soils present in the Colstrip area, their exact location and the extent each soil type can be stock-piled for best reclamation results. The soil scientists observed on site the steepness, length, and shape of slopes, the kinds of native plants and crops, and the mineralogical composition of the rocks. They also established soil profiles which are the sequence of natural layers or horizons, and extend from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots, by boring many holes. The profiles were compared with profiles in nearby counties and in more distant places. The soils were classified and named according to uniform procedures, the soil series and the soil phase being the categories of soil classification most used in this survey.

Soils with similar profiles make up a soil series. Each soil series is named after a geographic feature near the place where it was first observed and mapped. All the soils in the United States of the same series name are essentially alike in those characteristics that affect their behavior in the undistrubed landscape.

The surface layer of soils of the same series can differ in texture, slope, stoniness, or other land use characteristics. On this basis, soil series are further divided into phases. The name of a soil phase indicates a feature that affects management.

After a guide for classifying and naming the soils had been worked out, the boundaries of the individual soils on aerial photographs were drawn. Very detailed photographs that help draw accurate boundaries were used. The soil boundaries were later transferred to the accompanying topographic map (scale: 1" = 200'). Contour intervals are 5 feet.

In many surveyed areas where the soil material was rocky, shallow, severely eroded, or very variable, classification by series was impossible. Such locations are identified on the soil map and are described in the survey, but are called land types and are given descriptive names. In the Colstrip area a miscellaneous land type occasionally occurs in complex (in small pockets 20 feet across) within a soil type.

During the soil survey sampling of soil samples for laboratory measurements and for engineering tests was also done. A compilation of chemical analysis of the soil types follows.

Uses of the Soil Survey and Laboratory Analysis

The soils map together with the laboratory analyses furnish useful information in predicting soil behavior. Engineers use the information in predicting stability of slopes to earth structures, ease of soil compaction, susceptibility to piping, and corrosion of buried metals and concrete. Land use planners use the information in selecting building sites, parks, roads and industrial zones. Agronomists use the information in estimating the type and quantity of required soil for reseeding mined area; for crop selection and varieties, fertility treatments, and reclamation of soils with special chemical deficiencies.

CUSHMAN SERIES

The Cushman Series consists of moderately deep, well-drained soils formed from weathered soft sandstone and siltstone. They occupy uplands and are underlain by sandstone and siltstone, at depths of 20 to 40 inches.

Annual precipitation is 10 to 14 inches.

In a representative profile the surface layer is grayish-brown loam about 6 inches thick. The subsoil is brown clay loam about 2 inches thick. Below this lies a calcareous loam which grades to fine sandy loam. This merges with soft sandstone and shale at about 38 inches. Slopes are 2 to 8 percent.

Permeability is moderate and runoff is medium.

Typifying Pedon:

Typical profile of Cushman loam, 2 to 8 percent slopes:

Ap-0-6 inches, light brownish-gray (2.5y 5/2) loam, dark grayish-brown (2.5y 4/2) moist; moderate fine crumb structure; soft when dry, very friable when moist and nonsticky and nonplastic when wet; clear wavy boundary.

B2t-6-8 inches, brown (10yR 5/3) clay loam, dark brown (10yR 4/3) moist; moderate medium prisms that separate to moderate medium and fine subangular blocks; hard, friable, sticky and plastic; clay films on pads; common fine and very fine roots; many fine and very fine pores; no effervescence; clear wavy boundary.

B3ca-8-18 inches, light gray (2.5y 7/2) heavy loam, olive brown (2.5y 4/3) moist; weak coarse plates that separate to moderate medium and fine subangular blocks; hard, friable, slightly stick and slightly plastic; common fine and very fine roots; many fine and very fine pores; strong effervescence; common films of lime; clear wavy boundary.

C1ca-18-24 inches, light gray (2.5y 7/3) fine sandy loam, light olive brown (2.5y 5/4) moist; massive; very hard, very many fine and very fine pores; strong effervescence; many fine filsm and threads of lime; diffused boundary.

C2-24-48 inches, light yellowish-brown (2.5y 6/3) fine sandy loam, light olive-brown (2.5y 5/4) moist; massive; hard, very friable, non-sticky and non-plastic; few very fine roots; common fine and very fine pores; strong effervescence.

C3-38-50 inches, pale-brown, soft, shattered, well-weathered sandstone and residual loamy fine sand; sandstone fragments are undercoated with lime.

Cushman loam, 2 to 8 percent slopes (Ca). This soil is located on gently and moderately sloping uplands. The profile is typical for the series.

Risk of erosion is moderate for water and slight for wind.

Recommendations for Stockpiling:

The top 3 feet of soil are well suited for stockpiling. Locally the material is suitable to a depth of 4 to 6 feet. It is easily worked, has high natural fertility and roots penetrate well. The underlying soft sandstone and loamy shale is undesirable for stockpiling because of slow infiltration and slow internal permeability.

DWYER SERIES

The Dwyer Series consists of deep, well-drained, gently rolling and moderately sloping, calcareous soils on fans and upland slopes. These soils are formed in Aeolean sands and alluvium. Annual precipitation is 10 to 14 inches.

In a typical profile, the surface layer is grayish brown loamy fine sand about 6 inches thick. The substratum is pale brown with light brownish gray loamy fine sand. It is strongly calcareous.

Permeability is rapid, and runoff is slow.

Typifying Pedon:

Dwyer loamy fine sand, 4 to 10 percent slopes:

A1-0-6 inches, grayish-brown (10yR 5/2) loamy fine sand, dark grayish-brown (10 yR 4/2) moist; weak fine crumb structure; soft, very friable, nonsticky and nonplastic; weak effervescence; gradual wavy boundary.

C1-6-36 inches, pale brown (10 yR 6/3) loamy fine sand, dark grayish-brown (10 yR 4/2) moist; very weak medium and coarse subangular block structure; soft, very friable, nonsticky and nonplastic; common fine and very fine and few medium and coarse roots; common fine and very fine and few medium and large pores; strong effervescence; gradual boundary.

C2-36-72 inches, light brownish-gray (10 yR 6/2), loamy fine sand with few angular sandstone fragments, dark grayish-brown (10 yR 4/2) moist; massive; soft, very friable, nonsticky and nonplastic; common fine and very fine and few medium and coarse roots; common fine and very fine and few medium and large pores.

Dwyer loamy fine sand, 4 to 10 percent slopes (Da). This soil is located on moderately sloping fans and foot slopes. The profile is typical for the series.

Risk of erosion is slight for water and severe for wind.

Recommendations for Stockpiling:

This soil is suitable for stockpiling to a depth of at least 5 feet up to a depth at which the underlying material remains basically the same. The quality of this soil as a source of topsoil can be greatly improved when mixed with finer textured soils which will increase the water holding capacity and decrease the risk of wind erosion.

ELSO SERIES

The Elso Series consists of shallow, well-drained soils formed from weathered sandstone and siltstone. They occupy uplands and are underlain by sandstone and siltstone in depths of 6 to 20 inches. Annual precipitation is 10 to 14 inches.

In a representative profile the surface layer is light brownish-gray calcareous loam about 5 inches thick. Below this is a light gray loam about 6 inches thick that merges with soft sandstone and siltstone at a depth of about 11 inches. Slopes are 10 to 50 percent.

Permeability is moderate and moderately slow, and runoff is moderately rapid.

Typifying Pedon:

Typical profile of Elso loam:

A1-0-5 inches, light brownish-gray (2.5y 6/2) loam, grayish-brown (2.5y 5/2) moist; moderate fine granular structure; soft, very friable, nonsticky and nonplastic; weak effervescence; clear wavy boundary.

C1-5-11 inches, light-gray (2.5y 7/3) loam, light yellowish-brown (2.5y 6/3) moist; moderate medium platy structure; slightly hard, very friable, nonsticky and nonplastic; many fine and very fine pores; strong effervescence; clear wavy boundary.

C2-11-28 inches, white (2.5y 8/2) very soft platy siltstone that rubs to silt loam, light brownish-gray (2.5y 6/2) moist; few fine and very fine roots; strong effervescence.

Elso-McRae loams, 15 to 35 percent slopes (Ec). This complex occupies steeply sloping uplands and fans and footslopes. The Elso loam located on the ridges and rounded hills and the McRae loam is found on the fans and footslopes along the drainages.

The complex is about 60 percent Elso soil and 20 percent McRae soil. Each soil has a profile similar to the type described for the series. About 15% of each area consists of Cushman loam which occurs in small rolling areas within the over-all landscapes and about 5% of each mapped area is composed of shale outcrop.

Risk of erosion is severe for water and slight for wind.

Recommendations for Stockpiling:

All the soil material above the soft shale siltstone in the Elso loam part of this complex is suitable for stockpiling. The soil depth is approximately 1 foot, but locally can be less than 1 foot or nearly as much as 2 feet. The underlying soft shale and siltstone is undesirable for stockpiling because of slow rate of water intake.

The McRae loam is suitable for stockpiling to a depth of at least 5 feet or lower as deep as the texture is no finer than silty clay loam.

Elso loam 4 to 15 percent slopes (Eb). This soil is found on rolling to moderately steep shale uplands. Slopes are short and mainly 8 to 12%. The profile is typical for this series.
Included in the mapping are narrow bands of Cushman loam in concave positions on the landscape and small spots of shale outcrop.

Recommendations for Stockpiling:

The soil above the bedrock is suitable for stockpiling. The soil depth is approximately 1 foot but locally ranges between less than 1 foot to nearly 2 feet. The underlying soft shale and siltstone is undesirable for stockpiling because of slow rate of water intake.

Elso loam, 15 to 50 percent slopes (El). This soil is found on steep ridges and rounded hills on the uplands. The profile is typical for this series. Small areas of shallow clay loam soils and fine sandy loam soils are included.
Risk of erosion is severe for water and slight for wind.

Recommendations for Stockpiling

Only the soil above the bedrock is suitable for stockpiling. The soil depth is approximately 1 foot, but locally ranges from less than 1 foot to slightly more than 1 foot. The underlying soft shale and siltstone is undesirable for stockpiling because of slow rate of water intake.

FORT COLLINS SERIES

The Fort Collins Series consists of deep, well-drained soils formed from alluvium derived of soft sandstone and siltstone of the uplands. They occupy terraces and fans. Annual precipitation is 10 to 14 inches.
In a representative profile the surface layer is grayish-brown loam about 6 inches thick. The subsoil is brown silty clay loam about 6 inches thick. Below this is calcareous loam and silt loam. Slopes are 0 to 8 percent. Permeability is moderate and runoff is medium.

Typifying Pedon:

Fort Collins loam, 0 to 2 percent slopes:

Ap-0-6 inches, grayish-brown (10yR 5/2) loam, dark grayish-brown (10yR 4/2 rubbed and 3/2 rubbed) moist; moderate fine crumb structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; abrupt wavy boundary.

B2t-6-12 inches, brown (10yR 5/3) light silty clay loam, dark brown (10yR 4/3) moist; moderate medium and coarse prisms that separate to moderate medium and fine subangular blocks: hard, friable, slightly sticky and plastic; common fine and very fine roots; many fine and very fine pores; no effervescence; clear wavy boundary.

B3ca-12-23 inches, light yellowish-brown (2.5y 6/4) loam, light olive-brown (2.5y 5/4) moist; moderate medium and fine subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common fine and very fine roots; many fine and very fine pores; strong effervescence; few faint threads of line; clear boundary.

C1ca-23-48 inches, light gray (2.5y 7/2) silt loam, light olive-brown (2.5y 5/4) moist; massive; hard, friable; slightly sticky and slightly plastic; common fine and very fine roots; many fine and very fine pores; strong effervescence; few faint threads of lime; clear boundary.

C2-48-72 inches, light gray (2.5y 7/2) silt loam, light olive-brown (2.5y 5/4) moist; massive; hard, friable, nonsticky and slightly plastic; few very fine roots; common fine and very fine pores; st strong effervescence; few fine threads of gypsum crystals.

Fort Collins loam, 0 to 2 percent slopes (Fa). This soil is found on nearly level terraces and very gently sloping fans. It has the profile described as typical for the series. Wind and water risk is slight.

Recommendations for Stockpiling:

This soil is suitable for stockpiling to a depth of at least 5 feet or as deep as the underlying material remains basically the same.

HELDT SERIES

The Heldt Series consists of deep, well drained calcareous soils formed in alluvium. They occupy fans. Slopes range from 2 to 8 percent. Annual precipitation is 10 to 14 inches.

In a representative profile the surface layer is grayish-brown silty clay loam about 6 inches thick. The subsoil is light grayish brown silty clay loam about 16 inches thick. The underlying material is pale brown heavy loam or clay loam.

Permeability is slow and runoff is medium.

Typifying Pedon:

Heldt silty clay loam, 2 to 8 percent slope:

A1-0-6 inches, dark grayish-brown (10yR 4/2) moist; silty clay loam; moderate fine granular structure; slightly hard when dry, friable when moist; and sticky when wet.

B2-6-22 inches, grayish-brown (10yR 5/2) moist; silty clay loam; coarse blocky structure; hard when dry, friable when moist; and sticky when wet; strong effervescence; small nodules and fine threads of segregated lime.

C1-22-34 inches, pale-brown (10yR 6/3) moist; heavy loam; massive; hard when dry, friable when moist and slightly sticky when moist; strong effervescence.

C2-34-44 inches, pale-brown (10yR 6/3) moist; heavy loam; massive; hard when dry; friable when moist and slightly sticky when wet; strong effervescence.

C3-44-60 inches; brown (10yR 5/3) moist; sandy loam; massive; slightly hard when dry, very friable when moist and nonsticky when wet; strong effervescence.

Heldt silty clay loam, 2 to 8 percent slopes (Ha). This soil is located on gently and moderately sloping fans in upland valleys. The profile is typical for the series.
Risk of erosion is moderate for water and slight for wind.

Recommendations for Stockpiling:

This soil is suitable for stockpiling to a depth of 5 feet or below as deep as the underlying material remains basically the same. The quality of this soil as a source of topsoil, can be greatly improved when decreasing the relative clay content by mixing it with coarser texture soils such as the Tullock fine sandy loam or the Dwyer loamy fine sand which will improve the workability and increase the rate of water intake.

HAVERSON SERIES

The Haverson Series consists of deep, well-drained, calcareous soils formed in alluvium. They occupy flood plans along drainages and on fans. Slopes range from 0 to 8 percent. Annual precipitation is 10 to 14 inches.
In a representative profile, the surface layer is grayish-brown loam about 6 inches thick. The substratum is light brownish-gray and grayish-brown loam stratified with loamy fine sand.
Permeability is moderate and runoff is slow on the nearly level flood plains and medium on the fans.

Typifying Pedon:

Typical profile of Haverson loam:
A1p-0-6 inches, grayish-brown (2.5y 5/2) loam, dark grayish-brown (2.5y 4/2) moist; moderate fine crumb structure; slightly hard, very friable, nonsticky and slightly plastic; weak effervescence; abrupt wavy boundary.

A12-6-17 inches, grayish-brown (3.5y 5/2) silt loam, very dark grayish-brown (2.5y 4/2) moist; very weak fine and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and very fine roots; many fine and very fine pores; strong effervescence; clear smooth boundary.

C1-17-24 inches, grayish-brown (2.5y 5/2) loam, very dark grayish-brown (2.5y 3/2) when moist; massive; hard, friable, slightly sticky and slightly plastic; common fine and very fine pores; strong effervescence; few fine threads of lime; clear wavy boundary.

C2-24-52 inches, light brownish-gray (2.5y 6/3) loam, grayish-brown (2.5y 5/3) moist; massive; hard, very friable, nonsticky and slightly plastic; common very fine roots; many fine and very fine pores; strong effervescence; clear boundary.

C3-52-66 inches, light brownish-gray (2.5y 6/3) loamy fine sand, olive brown (2.5y 4/4) moist; massive; very friable, nonsticky and nonplastic; few fine and very fine roots; strong effervescence.

Haverson silt loam, fan phase, 2 to 8 percent slopes (Hv). This soil is found on gently and moderately sloping fans in upland. The profile is typical for the series, except it contains more lime and other salts. Risk of erosion is severe for water and moderate for wind.

Recommendations for Stockpiling:

The upper 2 feet of this soil are suitable for stockpiling. Salts that are not conducive to plant growth are present below this approximate depth. Material containing visible salts should be avoided for stockpiling.

Haverson loam, 0 to 2 percent slopes (Hvg). This soil is found on nearly leveled flood plains along drainages. It has the typical profile for the series.

Risk of erosion is slight for water and moderate for wind.

Recommendations for Stockpiling:

This soil is suitable for stockpiling to a depth of at least 5 feet or below as deep as the underlying material remains basically the same. The water table at some depth greater than 5 feet generally occurs in this soil.

McRAE SERIES

The McRae Series consists of deep, well-drained nearly level to moderately sloping, calcareous soils on fans and terraces. These soils are formed in loamy alluvium. Annual precipitation is 10 to 14 inches.
In a typical profile the surface layer and subsoil are light brownish-gray loam about 12 inches thick. The substratum is light gray loam and fine sandy loam. It is strongly calcareous and contains light gray masses of lime.
Permeability is moderate, and runoff is medium.

Typifying Pedon:

McRae loam, 4 to 8 percent slopes:

Ap-0-6 inches, light brownish-gray (2.5y 6/2) loam, dark grayish-brown (2.5y 4/2) moist; moderate fine crumb structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; strong effervescence; abrupt wavy boundary.

B2-6-12 inches, light brownish-gray (2.5y 6/2) loam, olive brown (2.5y 4/4) moist; moderate medium prisms that separate to weak medium and fine subangular blocks; slightly hard, friable, slightly sticky and plastic; common fine and very fine and few medium roots; many fine and very fine pores; strong effervescence; clear wavy boundary.

B3ca-12-20 inches, pale-yellow (2.5y 7/3) loam, light olive-brown (2.5y 5/4) moist; weak coarse subangular blocks; hard, friable, slightly sticky and plastic; common fine and very fine roots; common fine and very fine pores; strong effervescence with common faint masses and threads of lime; diffused boundary.

Clca-20-24 inches, pale-yellow (2.5y 7/3) loam, light olive-brown (2.5y 5/4) moist; weak medium subangular blocky structure; hard, friable, sticky and plastic; common fine and very fine roots; many fine and very fine pores; strong effervescence; few faint masses and threads of lime; gradual boundary.

C2-24-60 inches, pale-yellow (2.5y 7/3) fine sandy loam, olive-brown (2.5y 4/4) moist; massive; slightly hard, very friable, slightly sticky and nonplastic; few fine and very fine roots; strong effervescence.

McRae silty clay loam, 2 to 8 percent slopes (Ma). This soil is found on gently and moderately sloping fans in upland valleys. The profile is typical for the series, except that the surface layer and the subsoil are composed of silty clay loam to about 24 inches.
Risk of erosion is moderate for water and slight for wind.

Recommendations for Stockpiling:

This soil is suitable for stockpiling to a depth of at least 5 feet or below as deep as the underlying material remains basically the same. The quality of the upper two feet of this soil as a source of topsoil can be improved by mixing it with other soils such as the Tullock sandy loam, the Remitt fine sandy loam or the McRae loam.

McRae loam, 2 to 8 percent slopes (Mb). This soil is found on gently and moderately sloping fans in upland valleys. The profile is typical for the series.
Risk of water and wind erosion is moderate.

Recommendations for Stockpiling:

This soil is suitable for stockpiling to a depth of at least 5 feet or lower as long as the soil texture is not finer than silty clay loam or clay loam. Shale and sandstone bedrock may underlie the soil at 3 to 5 feet where the fans merge with steeply rising uplands that border the valleys. Such areas are confined to narrow 100 to 150 feet wide bands following the contour of the uplands.

McRae loam, 0 to 2 percent slopes (Mc). This soil is found on nearly leveled terraces. The profile is typical for the series.
Risk of erosion is slight for both water and wind.

Recommendations for Stockpiling:

This soil is suitable for stockpiling to a depth of 5 feet. As indicated in maps, there are large areas of usable depths of 6 to 8 feet. Below the 8 foot depth unsuitable textures of clay loam or silty clay loam may be encountered along the main drainageways of the large fans.

McRae-Elso loams, 6 to 15 percent slopes (Mcc). This complex comprises moderately steep soils found on rolling uplands and fans. It is composed of about 60% McRae loam, 25% Elso loam and 15% Cushman soils. The McRae loam occupies the fans and lower footslopes, and the Elso loam occupies the ridges and knolls. The McRae and Elso soils in this complex are similar to the ones described as typical for the serieis, except that in some of the McRae loam the depth to soft shales and sandstones is between 40 and 60 inches.
Risk of erosion is severe for water and moderate for wind.

Recommendations for Stockpiling:

The McRae soil in this complex is suitable for stockpiling to a depth of 5 feet. Below this depth it is suitable only if the texture is not finer than silty clay loam.

The Elso soil is suitable stockpiling but has a depth range of 1 to 2 feet over the underlying soft shale and siltstone.

McRae loam, 15 to 35 percent slope (Mt). This mapping unit consists of eroded, disected edges of fans along drainageways, and the narrow floor of the drainageways. The unit follows the course of the drainageways and is seldom more than 200 feet wide. The slopes are short and steep on the sides of the drainageways and leveled on the bottom.
The soil profile differs from the normal McRae in that erosion has removed the upper leyers, and the subsoil below 20 inches is more variably stratified with textures of silt loam and fine sandy loam.
Risk of erosion is severe for water and slight for wind.

Recommendations for Stockpiling:

The upper five feet of this soil is suitable for stockpiling. In the widest valleys the depth along the stream channel reaches up to 10 feet. The possibility of a water table below the 5 foot depth exists where sandstone bedrock or coal seams underlie the soil.

REMITT SERIES

The Remitt Series consists of deep, well-drained, moderately sloping and gently rolling soils on fans and footslopes. These soils are formed in sandy alluvium and aeolean sands. Annual precipitation is 10 ro 14 inches.

In a typical profile the surface layer and subsoil are grayish-brown find sandy loams about 12 inches thick. The substratum is light yellowish brown, strongly calcareious find sandy loam.

Permeability is moderately rapid, and runoff is slow.

Typifying Pedon:

Remitt find sandy loam, 4 to 8 percent slopes:

Ap-0-6 inches, grayish-brown (2.5y 5/2) fine sandy loam, dark grayish-brown (2.5y 4/2) moist; weak find crumb structure; soft when dry, very friable when moist; nonsticky and nonplastic when wet; weak effervescence; abrupt wavy boundary.

B2-6-12 inches, grayish-brown (10yR 5/2) fine sandy loam, dark-brown (10yR 4/3) moist; weak coarse prismatic structure; soft when dry, very friable when moist, nonsticky and nonplastic when wet; common fine and very fine and few medium roots, common fine and very fine pores; strong effervescence; clear wavy boundary.

Clca-12-36 inches, light yellowish-brown (2.5y 6/3) find sandy loam, light olive brown (2.5y 5/4) moist; massive; soft when dry, very friable when moist, nonsticky and nonplastic wet; common fine and very fine roots; common fine and very fine pores; strong effervescence and few fine, faint threads and masses of line; diffused boundary.

C2-36-60 inches, light yellowish-brown (2.5 6/3) fine sandy loam light olive brown (2.5y 5/4) when moist; massive; soft, very friable, nonsticky and nonplastic; few fine and very fine roots; strong effervescence.

Remitt Fine Sandy Loam, 2 to 8 percent slopes (Rb). This soil is found on gently to moderately sloping fans in upland valleys. The profile is typical for the series. Included are some areas of Remitt loam.

Risk of erosion is slight for water and severe for wind.

Recommendations for Stockpiling:

The upper 5 feet of this soils is suitable for stockpiling. Locally, where the fans merge with deep alluvial soils along major drainageways, the suitable depth may reach up to 8 feet. The water holding capacity of the material below 12 inches would be improved for use as topsoil if mixed with material of clay loam or silty clay loam texture.

Remitt Fine Sandy Loam, Red Phase, 2 to 8 percent Slopes (Rc). This soil is found on gently and moderately sloping fans in replaced valleys. It differs from the profile described as typical for the series in being red.

Risk of erosion is slight for water and severe for wind.

Recommendations for Stockpiling:

The upper 5 feet of this soil is suitable for stockpiling. Locally, where the fans merge with the soils along major drainageways, the usable depth may reach up to 8 feet. The material below 2 feet, being low in organic matter and clay is easily wind eroded.

Shale Outcrop-Elso Complex, Very Steep (Sa). This complex is found on very steep broken slopes of the uplands. Elso loam is on ridges and knolls and on some of the steep side slopes. Loamy and clayey shale outcrops are mainly present on very steep slopes.

This complex is about 60% shale outcrop and about 30% Elso soil. The Elso soil has a typical profile for the series. About 10% of each mapped area consists of shallow clay and clay loam soils.

Risk of erosion is severe for water and moderate for wind.

Recommendations for Stockpiling:

None of this mixture of shallow soil material and raw shale is suitable for stockpiling. Slopes of more than 25% and the predominance of shale outcrops on the landscape make excavation difficult.

Red Rock Outcrop Complex, Steep (Sb). This complex comprises red rock outcrops and steep soils on uplands. About 60% is red rock outcrop and about 20% is Remitt fine sandly loam, red phase.

Included in mapping is about 20% soils that are 1- to 20 inches deep from red bedrock. The Remitt soil has a typical profile for the series, except that it is red in color.

Risk of erosion is moderate for water and wind.

Recommendations for Stockpiling:

None of this very shaley, channery and gravelly loam material is suitable for stockpiling. The isolated pockets of Remitt soils are so small, discontinuous, and of such steep slopes that they are impractical to excavate by conventional methods. Material coarser than 3 inches makes up 30 to 75% of the volume of the identifiable soils in these areas.

THURLOW SERIES

The Thurlow Series consists of deep, well-drained, gently sloping soils on fans. These soils are formed in clayey alluvium. Annual precipitation is 10 ro 14 inches.

In a typical profile the surface layer is light brownish gray clay loam about 6 inches thick. The subsoil is heavy silty clay loam about 11 inches thick. The calcareous substratum is pale brown heavy silty clay loam and clay loam.

Permeability is moderately slow, and runoff is medium.

Typifying Pedon:

Typical profile of Thurlow clay loam, 1 to 4% slopes:

Ap-0-6 inches, light brownish-gray (10yR 6/2) clay loam, dark grayish-brown (10yR 4/2) moist; moderate fine crumb structure; hard when dry, friable when moist, sticky and plastic when wet; abrupt wavy boundary.

B21t-6-10 inches, grayish-brown (10yR 5/2) silty clay loam, brown (1-yR 4/3) when crushed with dark grayish-brown (10yR 4/2) coats when moist; moderate medium prisms that separate to strong fine and medium subangular blocks; hard when dry, friable when moist; and sticky and plastic when wet; common fine and very fine roots; many fine and very fine and few medium roots; clear wavy boundary.

B22t-10-17 inches, pale brown (10yR 6/3) heavy silty clay loam, brown (10yR 4/3) moist; moderate medium prisms that separate to strong fine and medium subangular blocks; hard, friable, sticky and plastic; common fine and very fine roots; many fine and very fine and few medium pores; strong effervescence; gradual wavy boundary.

Clca-17-36 inches, light yellowish-brown (2.5y 6/3) heavy silty clay
1 loam, olive brown (2.5y 4/4) moist; weak medium and find subangular blocky structure; hard, friable, sticky and plastic; common fine and very fine roots; many fine and very fine pores; few fine faint masses of line; strong effervescence; diffused boundary.

C2-36-60 inches, light yellowish-brown (2.5y 6/3) silty clay loam, light olive brown (2.5y 5/3) moist; massive; hard, very friable, sticky and plastic; few fine and very fine roots; few fine and very fine pores; strong effervescence.

Thurlow Clay Loam, 0 to 4 Percent Slopes (Ta). This soil is present on nearly level and gently sloping fans and terraces in upland valleys. The profile is typical for the series. Included are small areas of Heldt silty clay loam.

Risk of erosion moderate for water and slight for wind.

Recommendations for Stockpiling:

The soil material is suitable for stockpiling to a depth of 5 feet. Where slope gradient is 0 to 2 percent the usable depth ranges to 8 feet. The moderately slow permeability of the subsoil layer can be further reduced when the natural structure is destroyed by excavation. Where practical, this soil can be used to increase the clay content of the sandy and silty soils in the stockpile.

TULLOCK SERIES

The Tullock Series consists of moderately deep, well to somewhat excessively drained, sloping to moderately steep soils on sandstone uplands.

In a typical profile the surface layer is grayish brown light sandy loam about 6 inches thick. The substratum is loamy fine sand to 40 inches. It is calcareous with some disseminated lime. The soil rests on soft sandstone at depths between 20 and 40 inches.

The permeability is moderately rapid and runoff is low.

Range in charateristics is mainly in the substratum which includes textures of fine sandy loam.

Typifying Pedon:

Typical profile of Tullock sandy loam:

Ap 0-6 inches, grayish-brown (10tr 5/2) sandy loam, dark grayish-brown (10yr 4/2) moist; moderate medium crumb structure; soft, very friable, non-sticky and non-plastic; weak effervescence; clear wavy boundary.

C1 6-11 inches, grayish-brown (10yr 5/2) loamy fine sand, dark grayish-brown (10yr 4/2) moist; weak medium and coarse prismatic structure; slightly hard, very friable, non-sticky and non-plastic; common fine and very fine roots; common fine and very fine pores; strong effervescence; clear wavy boundary.

C2ca 12-22 inches, light gray (2.5y 7/2) loamy fine sand, light olive-brown (2.5y 5/3) moist; weak medium subangular blocky structure; slightly hard, very friable, non-sticky and non-plastic; common fine and very fine pores; strong dissemination of line; violent effervescence; clear wavy boundary.

C3 22-40 inches, light gray (2.5 y 7/2) very soft sandstone that rules to loamy fine sand, light yellowish-brown (2.5y 6/4) moist; common fine and very fine roots in upper part; strong effervescence.

Tullock Complex, 2 to 20 percent Slopes (Tb). This complex comprises gently rolling to moderately steep soils on uplands. About 55% is Tullock sandy loam, about 25% Remitt fine sandy loam and 15% Dwyer loamy fine sand. Also included are small areas of sandstone outcrops. The Tullock sandy loam occupies convex areas and includes soils that are 10 to 20 inches deep to the sandstone bedrock. The Remitt and Dwyer soils occupy plain slopes and concave footslopes. Each soil has profiles typical for this series except that about 10% of the Tullock sandy loam is 10 to 20 inches deep to sandstone.

Risk of erosion is slight for water and severe for wind.

Recommendations for Stockpiling:

The soil material above the bedrock is suitable for stockpiling. Soil depths and textures vary widely within the limits of each soil series due to the complex soils pattern, wide slope range and the sandstone outcrops. The concave and plain slopes offer the best opportunities for material 3 to 4 feet thick over the underlying sandstone. Sharp ridge crests, knolls, and convex slopes of gradients more than 10% have less than 30 inch depth to the parent sandstone.

The upper 2 feet of the parent sandstone and shale are sufficiently weathered to allow excavation but the material is low in water holding capacity, natural fertility and has a wide range of the infiltration rates.

Tullock Fine Sandy Loam, 4 to 15 percent Slopes (Tc). This soil is found on sloping to rolling uplands that are the broad divides between major valleys. Slopes are smooth and broken only by shallow drainageways. Slope gradient is mainly 4 to 8 percent. Some sandstone outcrops cap the sharp ridges and there are small spots of Elso loam on narrow ridges and the crests of isolated knolls.

Less sandstone outcrop, less broken slopes, smoother slopes and the absence of the Remitt and the Dwyer soils separate this unit from the Tullock complex, 2 to 20 percent slopes.

The profile is typical of the series.

Recommendations for Stockpiling:

All the soil material above the bedrock sandstone is suitable for stockpiling. The soil depth is mainly 3 feet but locally, where slopes are concave or slope gradients are less than 6%, can be as deep as 5 feet.

Natural fertility and water holding capacity decrease rapidly below the surface 12 inches.

The underlying sandstone bedrock is weathered sufficiently in the upper 2 feet to allow excavation by earth moving equipment. This material is suited for stockpiling but has low water holding capacity, low fertility and rapid infiltration.

Areas of this mapping unit can usually be uniformly excavated with earth moving equipment.

Undifferentiated, Mined and Spoils (U).

This undifferentiated unit comprises open pit mine areas and spoil areas.

GENERAL - SOIL TESTS(1)

The following is a brief explanation of tests made in this soil survey.

Soil Reaction (pH)

Soil pH indicates acidity or alkalinity of a soil. Most Montana agricultural soils are somewhat alkaline.

pH below 5.5	Strongly acid soil
pH 5.5 to 5.9	Moderately acid soil
pH 6.0 to 6.5	Slightly acid soil
pH 6.6 to 7.2	Neutral soil
pH 7.3 to 7.7	Slightly alkaline
pH 7.8 to 8.4	Moderately alkaline soil

Organic Matter

Soil organic matter is a percentage of the humus content of the soil and does not include recent additions of straw, manure or sod. Humus increases granular structure in soils, serves as a source of energy for bacteria and other soil organisms, and facilitates aeration and water penetration. Organic matter is a source of nitrogen.

% ORGANIC MATTER *	
0-1.9	very low
2.0-3.5	low
3.6-4.9	medium
above 5.0	high

*These categories may vary slightly with elevation and soil texture.

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(1) Montana Testing Laboratories, Inc.

General Ratings for Major Plant Nutrients Test (0-6" depth)

Rating	* NO3--N to 4 Ft. LB/AC of N	Phosphrous	Potassium
very low	0-35	0-30	0-75
low	35-60	30-50	75-125
medium	60-90	50-75	125-250
high	>90	>75	>250

*Special sampling and sample handling must be followed. The above amounts and ratings of nitrogen are general and apply primarily to dryland. The nitrogen requirements for irrigated drops such as sugar beets and corn are greater. Recommendations for these crops account for a 10 lbs n/ton yield requirement, and % organic matter, previous crop, and manure applied.

Nitrate-Nitrogen (NO3-N)

This test is used along with organic matter determinations to make nitrogen fertlizer recommendations. The NO3-N is a measure of the N immediately available for plant uptake.

To be meaningful, samples for NO3-N must be taken to a depth of 4 feet. They should be separated by each foot level. Care must be taken after sample is taken to keep them from getting warm. They must be dried or frozen immediately.

Soil notrigen supply can be markedly affected by climatic conditions and past soil and crop management. Nitrate-Nitrogen accumulation in a four-foot profile on dryland can range from 0 to 250 pounds per acre and from 10 to 500 pounds per acre on irrigated land.

Nitrogen may be lost from the soil by plant removal, denitrification, or leaching. Leaching of soil nitrate presents a pollution hazard. Leaching can however, be controlled by proper management practices.

Phosphorus

The Weak Bray method is used to determine phosphorus levels by this laboratory. Soil tests and Montana State University research show a majority of our soils low in available phosphorus, and responds profitably to phosphate fertilizers. Phosphorus fixation in most soils is great. Phosphorus is not readily leached. It stays where it is placed in all but the sandiest soils. Therefore, plowdown or band applications which place it in the most active root zone are generally superior to top dressing.

Evaluation for Phosphate Tests

Low range indicates most crops need phosphorus added, and especially so nitrogen fertilizers are being used for improved yields.

Low range indicates most crops need phosphorus added, and especially so on irrigated or intensive yield fields.

Medium range indicates a selective response range with high yield crops and heavy prosphorus feeders needing additional phosphorus.

High range indicates limited needs. Certain high yield crops, heavy phosphorus feeders, or crops grown with large nitrogen applications may require additional added phosphorus. Application is normally limited to maintenance or starter amounts.

Excessive rates of phorphorus will reduce the availability of zinc and iron, which in the case of some sensitive crops (corn, beans, potatoes, and sugar beets) could cause an actual yield reduction.

If the soil has a high amount of line, the phosphorus recommendation will be modified. The method of application must also be considered.

Potassium

The level of potassium is determined by the ammonium acetate test. Most Montana soils contain adequate amounts of potassium. Soil tests have aided in determining deficiencies. Potassium moves more readily in soil than phosphorus. However, there is little danger of leaching loss in all but the sandiest soil.

Calcium, Magnesium, and Sodium

These three elements are analyzed as indicators of problems. In Montana little data relating Ca, Mg, or Na to crop response has been compiled, except for acid or alkaline soils.

The test for sodium identifies specific salts commonly causing salinity. These soils must have a soluble source of calcium to correct the situation. Gypsum, sulfuric acid, sulfur, calcium chloride, iron or aluminum sulfate may be used as a soil amendment to remove sodium. These materials will not be effective unless the soil is well drained and irrigation water is available for leaching.

SODIUM GUIDE

O.K.	Slightly Sodic	Strongly Sodic
0.2 MEQ/100 g.	2-4 MEQ/100 g.	4+ MEQ/100 g.

Salt Hazard (Conductivity)

Conductivity is a measure of the total soluble salt concentration in a soil. Soluble salts are present in all soils, however, saline soils contain an excess of soluble salts which inhibits seed germination and plant growth.

Salt Hazard	Rating	Some Crops Which Can Be Grown
0-2.0 mmhos/cm	O.K.	Most crops grow well
2.0-4.0	Slightly salty	Field beans, meadow foxtail and white dutch, alsike, red and ladino clover
4.0-8.0	Moderately salty	Grain crops, alfalfa, most grasses and vegetables except radish, celery and green beans
8.0-16	Strongly salty	Barley, sugar beets, Canada Wild Rye, Western Wheatgrass, Birdsfoot Trefoil and Rescue grass
16.0 plus	Very strongly salty	Very few crops will grow

Micronutrients

Research is helping us to better understand the deficiencies of soil micronutrients throughout Montana, and the related crop responses from their application. Micronutrient deficiency or toxicity can have just as much effect on crop production as any one of the major elements. However, the application of soil micronutrients should not be considered until the major elements are in balance.

The margin between deficiency and toxicity is quite narrow. Therefore, a soil test should be taken before corrective measures are suggested to avoid applying amounts of micronutrients which may be toxic to plants.

The following are general ranges of soil micronutrients:

Element	Test Used	Deficient or Low	Adequate	Toxic or Excessive
B	(Hot water sol.)	Less than 0.5PPM	1.0-2.0PPM	3PPM
Cu	(Copper by DPTA)	Less than 0.2PPM	1.0-4.0PPM	20 ?
Mn	(Manganese by DPTA)	Less than 1.0PPM	1.0-3.0PPM	50+?
Zn	(Zinc by DPTA)	Less than 0.5PPM	1.0+PPM	15+?
Fe	(Iron by DPTA)	Less than 5PPM	10PPM	?
SO4-S	(Ammonium Acetate)	Less than 5PPM	5+PPM	?

Other Tests - Lime

This test is an estimate of the free lime content in your soil. Results are rated into four categories according to their reactions with hydrochloric acid: (V) Violent-high; (M) Moderate-medium; (S) Slight-low; or (O) None.

Lime is usually found in the lower depth of the soil profile. However, many soils contain lime in the top soil. It may reduce nutrient availability. Free lime cannot be readily removed from the soil.

Soil Texture

This manual test refers to the coarsness or fineness of the soil. It indicates the relative amount of sand, silt, and clay. Soil texture affects water holding capacity, water movement, temperature, and aeration as well as the soil's nutrient supplying ability. All recommendations are adjusted to account for the effect of texture on crop production. Texture is shown as: (S) Sands, (LS) Loamy Sands, (SL) Sandy Loams, (L) Loam, (SIL) Silt Loam, (SCL) Sandy Clay Loam, (CL) Clay Loam, (SICL) Silty Clay Loam, (SC) Sandy Clay, (SIC) Silty Clay, (C) Clay.

Available Stored Soil Water (H_2O)

This test is essential in making an accurate fertilizer recommendation for dryland. It tells how many inches of water are in the soil and available for plant use.

The amount of water available to a plant will vary with soil texture. For example, in a loam soil, any moisture in the soil over 80% can be utilized by the growing plant whereas a clay soil must have at least 19% moisture before any can be utilized by the plant.

When the available moisture in inches and NO3-N is known to a depth of 4 feet it is possible to determine the most economical fertilizer application as well as reasonably predict yield potentials in bushels.

2.(a)(i) - SOIL ANALYSIS OF SOIL HORIZON FROM MAJOR SOILS

Soil Sampling Procedures for Laboratory Analysis

Soil samples for laboratory analysis were collected from hand dug pits. Individual horizons were identified according to procedures outlined in Agriculture Handbook No. 18, Soil-Survey Manual, USDA. Quart size samples were taken of each significant horizon from a vertical section of the pit. Horizons below 30 inches were sampled with a hand auger or mechanical soil probe.

Soil profiles were selected to represent the central concept of the soil series where ranges in characteristics were small, and where soil characteristics ranged broadly the profiles were selected to represent the extremes.

Sample Preparation

Soil samples were air dried and divided into two parts; one part was used for chemical analysis, the second part was kept for later use. Each sample was passed through a 10 mesh screen for mechanical analysis and a 20 mesh screen for chemical analysis.

Chemical Analysis

The following determinations were carried out on horizon sample material after screening (20 mesh).

(aa) pH - solution ratio 1:2

(ab) Conductivity - same as above

(ac) Sodium Adsorption Ration (SAR) - When amonium acetate in solution is greater than 1 me/100 gms.

(ad) Cation Exchange Capacity - When SAR was greater than 10. Either exchangeable sodium percentage (ESP) or SAR could be used to predict potential physical problems.

(ae) Texture - Mechanical Analysis (Hydrometer Method)

Macro Nutrients:
  Organic Matter
  Nitrate Nitrogen (DPS method)
  Phosphorus - weak bray (acid) method by MSU Testing Laboratory
  Potassium, Calcium, Magnesium, and Sodium (ammonium acetate soluble)
  Others:
    Sulfur - (NH_4 acetate soluble)
    Zinc, Iron, Manganese and Copper (Chelatable, DTPA extracted)
    Boron - hot water soluble

Results and Discussion (S10300 2.(a)(i)(aa to ae)

Only soil samples from Pit #6 and Area A were analyzed. Samples were not collected from Area E because: (1) the major soil series found on Area A and Pit #6 are also present in Area E, and (2) Pit #6 and Area A bordered Area E on both ends, (north and south) within about 3 miles, and therefore it is believed that results of Area A and Pit #6 apply also to the similar soils of Area E.

Soluble Salt Concentrations indicate that concentrations at all depths are well below levels that could cause germination injury. At a depth of 44-46" on Stop 7 of Pit 6, the concentration is higher in comparison with the rest of the area but even there it is well below levels (4 mmhos/cm) that would cause any injury to salt sensitive crops.

pH of all soils are alkaline, above pH 8.0. Very high lime concentrations are found in many Montana soils and account for raising pH levels above

8.0. In areas where the sodium levels are low, the higher pH should not have any adverse affect on vegetation.

Sodium (me/100gm of soils) was below 1.0 me/100gm of soil on all soils and at all depths. No physical problem associated with sodium dispensing is anticipated in these soils.

Sodium Adsorption Ratio (SAR)

It was not necessary to analyze the soils for SAR because their sodium concentrations were very low. To confirm this, Stop #5 and Stop #7 were analyzed and the obtained values were less than 3. Only soils with SAR values of 10 or more are considered to cause some physical problems that may require amendment and reclamation.

Cation Exchange Capacity (CEC)

Not applicable for these soils because of very low SAR value. CEC is required to calculate ESP.

Texture

The soils textures were determined by both "feel" and the hydrometer method. The particle size distribution of soils was found to be very suitable for water permeability. Textures were classed as sandy loam, loamy sand, loam, sandy clay loam, and sandy. Very little gravel or unweathered shale sandstone were found in the major soils. Unweathered sandstone was very soft with a possibility to "breakdown" very rapidly. Although the textures found in the area are very desireable for permeability, they have moderately low water holding capacity due to a high percentage of large pores. To sustain vegetation soils with this type of texture require frequent precipitation and high levels of plant nutrient. It may be desireable when revegetating these areas to add straw mulch to keep the soil wet during the germination period.

Macro Nutrients

Organic matter levels and nitrate nitrogen concentrations were determined to predict supplemental nutrient requirements for revegetation. Both were found to be in low levels (below 3%) in all major soils found in Pit #6. Concentrations of organic matter will be further reduced when stockpiled and mixed with soils from lower depths which very often are void of any organic matter. Thus, supplemental nitrogen becomes very important in establishing a permanent cover in this area. Many samples of Area A show a high enough level of nitrate nitrogen to indicate that supplemental nitrogen may not always be required.

Phosphorus (Weak Bray Method)

Phosphorus concentrations are very low (less than 30 ppm) in all major soils and depths. With increasing depth in some soils phosphorus levels tend to decrease, in other they remain constant. Thus, when stockpiled and mixed with lower depths, supplemental phosphorus will become important in establishing a permanent covers. Application of 80-100% of actual P_2O_5 requirements once or twice during the first year, or until grass is established, is recommended. After soil leveling, phosphorus tests should be done to establish exact required levels.

Potassium

The available potassium in these soils is generally low, (below 125 ppm). The lower depths are consistently lower than the surface top 12" and when mixed, supplemental potassium may become important in establishing a permanent cover.

Sulfur and Micronutrients

Sulfur concentrations in these soils are low (below 5 ppm). When mixed with soils of lower depths it can become necessary to supplement sulfur. Concentrations of micronutrient extractable in DTPA (Zinc, Iron, Manganese, and Copper) show adequate levels of all elements except zinc. However, mixing layers of various depths may cause a deficiency (less than 0.5 ppm), especially for legumes. Zinc concentrations were high in the Heldt soils series and low in the Remitt series, mixture of the two series that are associated in terms of location may not require supplemental zinc. The area near Stop 1 through 4 may require supplemental zinc to maintain growth of a permanent cover.

Soil Sample Analysis

Results of laboratory analyses are contained on the following pages.

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Date Rec'd 8-20-73

Date Sent

RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc
P. O. Box 2048
Great Falls, Montana 59404

FOR: Western Energy
(Grower)

Pit #6 Stop #1 D-

CLIENT:
(Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	[illegible] LIME
9082		0-36	8.5	0.6	1.85	22.2	12.5	88	30.2	3.0	0.1	0.3	L	X
9083		36-60	8.8	0.08	0	0	12.5	63	27.1	9.4	0.3	0.5	FSL	M+
9084		60-72	8.8	0.08	0	0	23.5	88	31.5	5.0	0.1	0.4	L-	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	~~Lime or Gypsum~~ SAR	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	~~Others~~ texture
	0.5	6.	1.2	6.4		6.75	3.37			10.8	12.4	76.8	SL
	0	4.0	1.4	3.4		14.9	7.45			24.8	12.4	62.8	SCL
	0.05	8.4	1.0	3.2		5.53	2.77			8.8	14.4	76.8	SL

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Date Rec'd. 8-27-73

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy

Pit 6 Stop 1A Da

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available ~~H_2O (Inches)~~
														LIME
8753	63	0-6	8.5	0.1	2.5	5.0	2.3	88	13.4	1.3	0.1	0.3	LFS+	S
8754	64	6-36	8.4	0.1	3.75	37.5	1.0	113	28.0	2.5	0.1	0.3	LFS+	M
8755	65	36-60	8.5	0.1	0.5	4.0	1.5	63	32.8	3.8	0.1	0.3	LFS+	M

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	~~Gypsum~~	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	TEXTURES
								SAR					
+138	0.15	15.5	2.9	4.4		5.64	2.82			8.8	8.4	82.8	LS
1.69	0.3	11.2	2.3	9.5		7.96	3.98			12.8	10.4	76.8	SL
						5.64	2.82			8.8	14.4	76.8	SL

Date Rec'd. 8-29-73
Date Sent

RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy
Pit #6 Stop #2 Rb

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	[illegible] LIME
9085		0-6	8.3	2.8	3.75	7.5	21.0	88	+35	2.0	0.1	0.5	LFS	M-
9086		6-36	8.3	0.7	1.85	18.5	14.5	63	+35	2.5	0.1	0.3	FSL	M
9087		36-60	8.5	0.08	0	0	17.5	63	+35	4.0	0.1	0.4	FSL	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	~~Lime or Gypsum~~ SAR	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others texture
0	4.4	1.2	12.[illegible]			7.0	3.5			10.8	12.4	76.8	SL
0	4.9	1.8	5.2			5.6	2.8			8.8	34.4	56.8	L
0.	4.0	1.2	4.0			5.62	2.81			8.8	4.4	86.8	S

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy
Pit #6 Stop #3 3 Rb

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	XXXXXXX XXXXXXX LIME
9088		0-7	8.2	1.3	3.0	6.9	32.0	63	12.1	1.6	0.1	0.4	FSL-	S
9089		7-24	8.1	0.5	0.5		17.5	2.5	30.2	2.7	0.1	0.4	FSL	M
9090		24-60	8.2	0.08	0		14.5	2.5	32.8	3.8	0.1	0.3	FSL-	M+
9091		60-72	8.2	0.08	0.5		14.5	63	11.3	4.6	0.1	0.3	LFS+	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	XXXXX texture
	0.3	3.8	1.8	10.8		6.83	3.42			10.8	2.4	86.8	LS
	0	3.9	1.4	4.4		5.58	2.79			8.8	8.4	82.8	LS
	0.6	2.4	1.6	3.2		6.8	3.4			10.8	2.4	86.8	LS
	0.45	4.0	1.4	2.4		5.62	2.81			8.8	4.4	86.8	S

Ind.-Obs. 2570 5500

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Date Rec'd. 8-29-73

Date Sent

RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc
P. O. Box 3048
Great Falls, Montana 59401

FOR: (Grower) Western Energy
Pit #6 Stop #4 Rb

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	[illegible]
														LIME
9092		0-6	8.0	2.6	0	0	29.5	188	4.1	3.0	0.1	0.3	FLS	0
9093		6-11	8.1	1.2	0.5	.85	21.0	150	9.5	3.8	0.1	0.2	FSL	0
9094		11-24	8.1	0.3	0	0	17.5	63	+35	4.6	0.1	0.3	FSL	M+
9095		24-60	8.2	0.08	0	0	29.5	113	+35	8.5	0.3	0.4	L-	M
9096		60-72	8.6	0.08	0.5	2.0	33.5	63	33.7	3.0	0.1	0.4	LFS-	M

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	[illegible]
													texture
	0.0	4.4	1.0	14.4		3.82	2.91			8.8	14.4	76.8	LS
	0	4.4	1.6	11.7		5.66	2.83			8.8	14.4	76.8	LS
	0	4.6	1.6	3.2		11.36	5.68			18.8	16.4	64.8	SL
	0	4.2	1.1	2.0		10.3	5.15			16.8	8.4	74.8	SL
	0	4.0	1.4	2.8		5.62	2.81			8.8	8.4	82.8	LS

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy
Pit #6 Stop #5 Ha

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	~~Available Water (Inches)~~ LIME
9097		0-4	8.2	1.3	5.0	6.5	21.0	63	17.7	1.8	0.1	0.5	L	M
9098		4-24	8.2	1.0	0	0	7.7	63	18.5	1.8	0.1	0.3	L	M
9099		24-36	8.2	1.1	0	0	14.5	63	+35	3.6	0.1	1.6	VFSL	M+
9100		36-60	8.3	0.08	5.55	44.4	12.5	88	29.7	4.1	0.1	1.8	L-	M+

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OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	~~OTHER~~ texture
								SAR					
	0.6	4.4	1.8	10.0		10.30	5.15	1.56		16.8	18.4	64.8	SL
	0	4.4	1.2	4.0		9.12	4.60	1.22		14.8	12.4	72.8	SL
	0	6.3	1.6	5.4		14.94	7.49	1.56		24.8	18.4	56.8	SCL
	0	4.9	1.4	2.8		6.78	3.39	0.78		10.8	24.4	64.8	SL

Ind.-Obs. 2570 5500

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Date Sent

RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy
Pit#6 Stop #6 Rb

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	LIME
9101		0-4	8.1	2.4	1.25	1.63	17.5	63	5.7	3.4	0.1	0.4	L	O
9102		4-9	8.2	1.4	0	0	17.5	88	6.2	2.7	0.1	0.3	L	O
9103		9-32	8.3	0.7	1.25	9.63	14.5	113	+35	4.3	0.1	0.4	L-	M
9104		32-63	8.5	0.08	0	0	17.5	63	24.5	8.7	0.1	0.4	FSL	M
9105		63-76	8.9	0.08	0	0	7.7	63	22.3	3.4	0.1	0.4	FSL	M

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	Others
								SAR					texture
	0	5.5	1.1	14.4		5.8	2.9			8.8	14.4	76.8	SL
	0	5.2	1.2	7.0		6.84	3.42			10.8	8.4	80.8	LS
	0	4.9	1.4	4.8		6.76	3.38			10.8	12.4	76.8	SL
	0.05	3.9	1.4	2.4		9.10	4.55			14.8	13.4	72.8	SL
	0	4.0	1.4	2.4		6.78	3.39			10.8	6.4	82.8	LS

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy
Pit #6 Stop #7 Wa

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	LIME
9106		0-6	8.3	2.7	1.85	3.7	14.5	213	7.5	3.2	0.1	0.4	FSL	M
9107		6-22	8.4	1.2	0	0	62.0	88	19.4	3.0	0.1	0.3	L+	M+
9108		22-34	8.5	0.6	0	0	12.5	88	+35	7.3	0.1	0.5	SiL	M+
9109		34-44	8.6	0.08	0	0	12.5	63	29.3	9.2	0.1	0.9	L	M
9110		44-64	8.3	0.08	0	0	21.0	63	29.3	6.2	0.5	2.9	SiL	0

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum SAR	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	~~Others~~ texture
	0.05	4.0	1.6	10.8		18.58	9.29	2.77		30.8	30.4	38.8	CL
	0	4.6	1.8	4.8		17.26	8.63	0.33		28.8	20.4	52.8	SCL
	0	5.2	2.0	3.6		19.5	9.75	0.32		32.8	26.4	40.8	CL
	0	7.0	1.6	2.8		18.38	9.19	1.22		30.8	24.4	44.8	SCL
	0	4.9	1.4	2.4		11.42	5.71	0.72		16.8	28.4	64.8	SL

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy
Pit #6 Stop #9

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	[illegible]
														LIME
9111		0-4	8.3	2.1	3.0	3.9	7.7	213	4.9	6.6	0.1	0.5	L	0
9112		4-13	8.4	0.5	1.25	3.75	65.5	63	34.9	5.7	0.1	0.7	L	M+
9113		13-24	8.3	1.3	0.5	1.85	7.7	63	20.3	3.2	0.1	0.4	L	M
9114		24-60	7.9	0.08	0	0	5.0	0	27.1	9.7	1.5	5.4	FSL	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
								SAR					texture
	0	4.6	1.6	17.8		15.05	7.52	0.67		24.8	32.4	42.8	L
	0	6.0	2.0	3.2		14.86	7.43	0.27		24.8	30.4	44.8	L
	0	6.3	2.0	4.8		14.95	7.48	0.17		24.8	14.4	50.8	SCL
	0	6.6	1.8	2.4		12.58	6.29	0.17		20.8	16.4	52.8	SCL

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy

Area A1 Stop 17 Rc Remitt

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
9010		0-14	7.7	1.0	0.25		14.5	213	10.0	5.0	0.1	0.5	FSL+	0
9011		14-20	7.9	0.5	0.25		12.5	88	32.4	3.8	0.1	0.3	FSL	M
9012		20-50	7.9	0.08	0.25		17.5	63	34.1	7.1	0.1	0.4	FSL+	M
9013		50-72	8.2	0.08	0.25		7.7	2.5	21.5	7.3	0.1	0.4	FSL+	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
3.4	0	7.0	2.3	10.0		11.8	5.9			26.8	34.4	38.8	L
0	0	4.9	1.4	5.2		9.06	4.53			14.8	30.4	54.8	SL
0	0	3.8	1.4	3.2		9.59	4.79			15.8	3.4	80.8	SL
0.7	0	3.0	1.1	1.4		9.59	4.79			15.8	2.4	81.8	SL

2570 5500

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc
P. O. Box 3048
Great Falls, Montana 59401

FOR: (Grower) Western Energy

Area A1 Stop 1 Ma McRae

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H_2O (Inches)
9035		0-6	7.9	2.9	22.95		17.5	213	20.3	5.3	0.1	0.6	SiCL-	LIME M-
9036		6-16	8.2	0.9	7.5		5.0	88	+35	8.0	0.1	0.5	L	M+
9037		16-24	8.3	0.1	1.85		5.0	63	+35	11.9	0.1	0.5	L+	M+
9038		24-36												
9039		36-66	9.0	0.1	0.25		21.0	2.5	34.1	8.0	1.0	0.6	L	M

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
													Texture
38	0.05	5.8	1.6	4.8		18.57	9.29			30.8	50.4	18.8	SiCL
4.1	0	5.5	2.0	5.2		11.78	5.89			26.8	34.4	38.8	L
43.4	0.3	4.6	1.8	2.8		14.92	7.46			24.8	46.4	28.8	L
18.2	0	4.0	1.2	3.4		7.96	3.98			12.8	48.4	38.8	L

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy
Area A1 Stop 2 Rb

CLIENT: (Dealer) ____________

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
														LIME
9031		0-6	8.0	1.2	9.0		17.5	238	9.1	3.6	0.1	0.4	L	O
9032		6-12	8.0	1.0	6.25		7.7	113	27.5	5.3	0.1	0.4	L	M
9033		12-36	8.2	0.5	3.0		5.0	113	34.9	6.9	0.1	0.4	L	H+
9034		36-60	8.4	0.08	0.25		12.5	63	32.4	8.7	0.1	0.4	FSL+	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
0.7	0	6.3	1.1	10.2		14.94	7.47			24.8	34.4	40.8	L
0.7	0	5.8	1.8	5.2		11.8	5.89			26.8	34.4	38.8	L
8.5	0	4.4	1.4	4.0		10.22	5.11			16.8	44.4	38.8	L
0.7	0	3.9	1.4	2.8		9.0	4.5			14.8	10.4	74.8	SL

Ind.-Obs. 2570 5500

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3043
Great Falls, Montana 59404

FOR: (Grower) Western Energy

Area A1 Stop 3 R[illegible]

CLIENT: (Dealer)

Lab No.	Your No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
														LIME
9027		0-6	8.1	0.08	16.25		17.5	150	20.3	2.5	0.1	0.5	[illegible]	
9028		6-12	8.1	0.6	5.0		12.5	88	32.4	3.2	0.1	0.3	SL	M
9029		12-36	8.1	0.08	3.[illegible]		14.5	62	24.1	4.8	0.1	0.4	FSL	M+
9030		36-60	8.3	0.08	14.8		7.7	63	30.2	5.9	0.1	0.3	FSL-	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
0.7													
3.4	0	4.4	1.1	4.2		9.65	4.82			15.8	19.4	64.8	SL
9.9	0	3.9	1.0	3.2		7.85	3.92			12.8	2.4	84.8	LS
0.7	0	5.8	1.1	2.8		9.0	4.5			14.8	30.4	54.8	SL

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Date Rec'd. 8-27-73

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy
Area A1 Stop 4 Rb

CLIENT: (Dealer)

Lime

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	[illegible]
8706	15	0-6	8.3	1.2			2.3	113	5.75	3.15	0.13	0.3	FSL-	0
8707	16	6-12	8.0	0.1			1.5	113	12.1	3.2	0.1	0.3	FSL	S
8708	17	12-36	7.9	0.1			0.5	350	28.9	4.55	0.1	0.4	FSL	M
8709	18	36-60	8.2	0.1			0.5	88	+35	10.3	0.3	1.4	FSL+	M+

OTHER TESTS REQUIRED SAR

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	Textures
0.7	0.3	7.0	2.0	5.8		7.98	3.99			12.8	6.4	80.8	SL
20.6	0.4	14.4	1.8	11.4		5.64	2.82			8.8	10.4	80.0	LS
0.7	0.22	28.8	2.3	19.4		12.6	6.3			20.8	7.4	72.8	SCL
127.1	4.65	13.8	2.3	7.4		10.28	5.14			16.8	26.4	56.8	SL

Date Rec'd. 8-27-73

Date Sent

RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, In
P. O. Box 2018
Great Falls, Montana 59404

FOR: (Grower) Western Energy

Area 21 Stop 5 Mb

CLIENT: (Dealer)

Lab No.	Your Field No	Depth (inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	[illegible]
														Lime
8710	19	0-6	8.0	1.2			1.0	150	25.9	3.1	0.1	0.5	L	M-
8711	20	6-12	8.0	0.5			0.5	88	+35	3.6	0.1	0.4	L	M
8712	21	12-20	8.1	0.1			0.5	88	15.5	6.1	0.1	0.3	L-	M+
8713	22	20-24	8.3	0.1			0.5	88	29.8	8.2	0.1	0.4	FSL+	M+
8714	23	24-36	8.6	0.1			1.0	63	30.7	8.5	0.1	0.3	FSL	M+
8715	24	36-60	8.8	0.1			0.5	88	30.7	8.0	0.1	0.3	FSL	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or ~~XXXX~~ Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	TEXTURES XXXXXXX XXXXOthers
								SAR					
	0.12	22.9	2.4	14.9		14.94	7.47			24.8	18.4	56.8	SCL
[illegible]	10.5	20.0	3.0	23.6		7.9	3.95			12.8	18.4	68.8	SL
8.5	0.6	21.5	3.0	30.0		14.92	7.46			24.8	2.4	72.8	SCL
9.9	4.5	21.5	3.0	30.0		15.8	7.9			12.8	18.4	68.8	SL
12.9	0.9	13.8	3.0	24.4		10.28	5.14			16.8	10.4	72.8	SL
9.5	0.55	16.6	3.0	28.0		16.8	7.[illegible]			12.8	10.4	76.8	SL

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy

Area A1 Stop 6 Mb

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	~~[illegible]~~ LIME
8716	25	0-6	8.4	1.4			3.0	238	7.5	4.2	0.1	0.4	L+	0
8717	26	6-12	8.3	0.6			1.5	188	26.7	5.7	0.1	0.4	L+	M
8718	27	12-24	8.5	0.1			0.5	88	+35	5.9	0.1	0.4	L	M+
8719	28	24-36	8.8	0.1			0.5	63	34.6	9.9	0.1	0.3	L-	M+
8720	29	36-60	8.8	0.1			0.5	63	32.8	7.8	0.1	0.4	FSL	M+

OTHER TESTS REQUIRED

TEXTURES

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	~~[illegible] of Gypsum~~ SAR	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	XXXXX Others
6.98	0.6	13.5	2.6	21.7		17.28	8.64			28.8	18.4	52.8	SCL
0	0.22	10.9	2.8	8.6		10.24	5.12			16.8	16.4	56.8	SCL
0	0.10	8.4	2.4	4.8		14.92	7.46			24.8	18.4	56.8	SL
6.1	0.3	9.8	2.4	4.0		12.6	6.3			20.8	14.4	64.8	SCL
19.8	0.3	11.9	2.6	3.2		9.12	4.56			14.8	22.4	62.8	SL

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, In
P. O. Box 2048
Great Falls, Montana 59404

FOR: (Grower) Western Energy

Area41 Stop 7 Ta

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available [illegible] (Inches)
														LIME
8721	30	0-6	7.1	1.2			1.0	300	6.2	5.0	0.1	0.3	CL-	0
8722	31	6-10	7.1	0.8			1.5	188	7.9	8.0	0.1	0.4	SiCL+	0
8723	32	10-17	7.4	0.4			1.0	113	31.5	11.0	0.1	0.4	SiCL	M
8724	34	17-36	7.5	0.1			1.0	63	14.6	14.3	0.1	1.1	SiCL+	M+
8725	35	36-60	7.6	0.1			2.7	300	29.8	18.7	1.3	2.1	SiCL	M+

OTHER TESTS REQUIRED.

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	~~Lime or Gypsum~~	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	TEXTURE ~~Others~~
								SAR					
7.4	0.22	16.2	3.2	10.0		14.94	7.47			24.8	26.4	48.8	SCL
9.1	0.3	17.6	3.2	4.4		9.10	4.55			14.8	36.4	48.9	L
42.9	0.45	13.8	3.0	4.8		19.49	9.75			32.8	28.4	38.8	CL
+138	1.05	[illegible]	3.0	6.4		12.6	6.3			20.8	46.4	32.8	L
+138	0.15	11.9	2.5	6.2		11.79	5.9			26.8	36.4	36.8	CL

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy

Area A1 Stop 8 Hvg

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	~~Available Mo (Inches)~~ LIME
8726	36	0-6	7.9	1.3			4.3	275	18.1	3.0	0.1	0.4	L	S
8727	37	6-17	7.6	1.9			1.8	300	22.4	5.3	0.1	0.4	SiL+	S
8728	38	17-24	7.8	1.4			1.5	213	25.9	8.0	0.1	0.5	L+	S
8729	39	24-36	8.1	0.1			1.8	113	+35	13.1	0.1	0.4	L	M
8730	40	36-54	8.3	0.1			10.0	88	+35	12.6	0.1	0.6	L	M+
8731	41	54-66	8.2	0.1			1.8	88	30.7	7.8	0.1	0.8	FSL	M

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	~~Lime or Gypsum~~ SAR	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	~~XXXXs~~ TEXTURES
42.9	0.1	10.6	2.8	4.8		5.66	2.83			8.8	26.4	64.8	SL
8.5	0.1	11.9	2.6	3.6		6.0	3.0			26.8	22.4	50.8	SCL
14.7	0.22	9.8	2.4	3.2		6.85	3.42			10.8	36.4	52.8	SL
68.2	0.65	19.0	2.6	10.2		14.92	7.46			24.8	12.4	62.8	SCL
70.1	0.22	18.0	2.9	5.4		9.12	4.56			14.8	20.4	64.8	SL
84.7	0.1	14.8	2.5	4.8		9.12	4.56			14.8	12.4	72.8	SL

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc
P. O. Box 3048
Great Falls, Montana 59404

FOR: Western Energy
(Grower)
Area A1 Stop 9 Tb

CLIENT:
(Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	~~Available H2O~~ LIME
8732	42	0-6	8.1	1.4			1.0	188	5.3	2.7	0.1	0.3	FSL	0
8733	43	6-12	7.9	0.4			0.75	113	5.75	2.5	0.1	0.3	FSL-	0
8734	44	12-23	8.0	0.1			0.75	63	+35	2.2	0.1	0.3	LFS-	M+
8735	45	23-44	8.3	0.1			1.0	88	28.9	2.2	0.1	0.2	LFS	M+

OTHER TESTS REQUIRED

TEXTURES

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	~~Lime or Gypsum~~ SAR	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	~~XXXXX~~
2.06	0.3	28.8	2.9	10.4		6.32	3.42			10.8	9.4	80.8	LS
1.38	0.22	25.5	3.2	6.4		4.43	2.21			6.8	2.4	90.8	S
2.75	0.40	20.8	2.8	5.2		5.64	2.82			8.8	4.4	86.8	LS
3.44	1.9	10.6	3.0	13.8		4.48	2.24			6.8	4.4	88.8	S

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3018
Great Falls, Montana 59404

FOR: Western Energy
(Grower) Area A1 Stop 10 Tb

CLIENT:
(Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	~~Available H_2O (Inches)~~ LIME
8736	46	0-6	8.0	0.9			4.3	88	7.5	2.2	0.1	0.4	FSL	0
8737	47	6-12	8.2	0.15			1.8	88	30.2	3.1	0.1	0.3	FSL-	M-
8738	48	12-22	8.3	0.1			1.5	88	34.1	2.6	0.1	0.3	LFS	M+
8739	49	22-40	8.7	0.1			1.5	88	26.7	4.5	0.1	0.3	LS	M

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	~~Lime or Gypsum~~ SAR	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	TEXTURES
4.1	0.4	25.0	2.4	20.2		4.78	3.39			10.8	2.4	86.8	LS
11.3	0	7.2	2.0	4.4		4.38	2.19			6.8	7.4	86.8	LS
12.9	0	5.5	2.0	3.4		3.6	4.3	1.36		14.8	2.4	82.8	LS
15.4	0	6.3	1.8	2.8		5.64	2.82			8.8	4.4	86.8	S

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, In
P. O. Box 3043
Great Falls, Montana 59104

FOR: (Grower) Western Energy
Area 41 Step 11 Ta

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Av[illegible] LT[illegible]
8740	50	0-6	8.3	1.0			4.3	300	28.9	8.2	0.1	0.3	SiCL	O
8741	51	6-10	8.0	0.8			2.3	300	9.5	0.3	0.1	0.3	SiCL+	O
8742	52	10-20	8.3	0.1	1.25	4.13	0.5	150	+35	16.4	0.1	0.4	SiCL+	M+
8743	53	20-28	8.6	0.1	0	0	2.7	150	30.7	14.3	0.1	0.4	SiCL+	M+
8744	54	28-48	8.2	0.1	1.25	4.13	4.3	188	+35	12.9	0.5	1.1	SiCL+	M+
8745	55	48-60	8.0	0.1	0	0	3.5	188	+35	11.9	1.3	4.3	SiCL+	M+

OTHER TESTS REQUIRED

TEXTURES

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	~~[illegible]~~ SAR	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	XXXXX ~~Others~~
9.1	0.15	9.8	2.4	8.2		20.72	10.36	2.44		34.8	24.4	40.8	CL
+138	0.22	11.5	2.2	3.6		9.10	4.55	0.16		14,8	36.4	48.8	L
+138	0	14.4	2.3	2.4		26.32	13.26	0.63		44.8	22.4	32.8	C
+138	0	12.2	1.8	12.0		14.92	7.46	0.07		24.8	36.4	38.8	CL
+138	0.3	14.4	2.6	12.8		27.68	13.84	0.06		46.8	24.4	28.8	C
+138	0.15	18.4	2.5	6.7		7.96	3.98	0.14		12.8	54.4	32.8	SL

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy
AreaA1 Stop 12 Hv

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available LIME
8746	56	0-9	7.9	0.3	0	0	2.7	150	31.1	3.2	0.1	3.6	L+	M+
8747	57	9-36	8.3	0.1	1.25	11.25	2.3	113	33.7	7.8	0.7	0.5	SiL+	M
8748	58	36-60	8.0	0.1	0	0	2.3	113	+35	12.4	2.1	5.4	L	M
8749	59	60-72	8.0	0.1	0	0	2.7	113	28.9	7.8	1.0	5.0	CL	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Gypsum SAR	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	TEXTUR XXXXX Others
+138	0	12.5	2.0	2.8				0.15					
+138	0.1	13.5	2.6	2.4		12.60	6.30	0.18		20.8	38.4	44.9	CL
16.2	0.4	26.4	2.6	16.8		6.8	3.4	0.32		10.8	28.4	60.8	SL
132.3	0.15	17.2	2.9	4.0		7.96	3.98	1.97		12.8	42.4	44.8	L

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy
Area A1 33 Stop 13 Tc

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	~~Available~~ [illegible]
8750	60	0-5	8.2	2.0	1.25	2.13	1.0	63	+35	4.1	0.1	0.8	SL+	LIME M-
8751	61	5-13	8.3	0.7	0	0	0.5	150	+35	4.1	0.1	0.5	SL+	M+
8752	62	13-60	8.5	0.1	0	0	0.75	150	34.9	6.4	0.3	0.5	SL	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	~~Lime (Dry)~~ ~~Gypsum~~	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	TEXTURS ~~[illegible]~~
[illegible]	0.22	11.9	2.5	3.4		11.56	5.78	SAR		18.8	16.4	64.8	SL
46.8	0.15	19.2	2.6	9.2		7.92	3.96			12.8	14.4	72.8	SL
+138	0.1	13.5	2.3	5.8		6.3	3.4			10.8	14.4	74.8	SL

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3048
Great Falls, Montana 59404

FOR: (Grower) Western Energy

Area A1 Stop 14 Ma McRae

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
9022		0-5	8.1	1.9	0.25		17.5	275	31.5	6.2	0.1	0.4	SiCL-	LIME M
9023		5-11	8.2	0.8	0.5		14.5	150	10.9	5.7	0.1	0.4	SiL+	M
9024		11-20	8.2	0.4	3.75		7.7	63	+35	6.6	0.1	0.4	L	M
9025		20-36	8.5	0.08	0.5		17.5	88	32.4	8.2	0.1	0.4	L	M
9026		36-72	8.6	0.08	1.85		23.5	2.5	30.7	5.9	1.0	1.1	FSL	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
0.7	0	7.2	2.2	20.2		18.5	9.25			30.8	50.4	18.8	SiCL
0.7	0	5.5	1.8	9.5		17.2	8.6			28.8	52.4	18.8	SiCL
0.7	0	7.5	1.4	7.0		11.72	5.86			26.8	34.4	38.8	L
19.8	0	4.0	1.4	3.4		14.81	7.41			24.8	31.4	42.8	L
8.5	0	5.2	1.4	3.6		11.34	5.67			18.8	10.4	70.8	SL

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Laboratories, I
P. O. Box 3013
Great Falls, Montana 59404

FOR: (Grower) Western Energy

Area A1 Stor 15 Elso

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inch)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Avail H2((Inch
9019		0-5	8.0	1.4	0.25		7.7	188	28.9	3.4	0.1	0.4	L	LI. M
9020		5-11	8.2	1.2	1.25		14.5	150	28.0	3.2	0.1	0.4	L	M+
9021		11-28	8.4	0.1	0.5		33.5	113	24.5	5.9	0.3	0.7	VFSL	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
1.4	0	4.6	1.8	10.2		10.32	5.16			16.8	42.4	40.8	L
6.1	0	5.8	1.6	5.2		9.14	4.57			14.8	46.4	38.8	L -
105	0	5.5	1.2	3.6		10.28	5.14			16.8	4.4	78.8	SL

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3013
Great Falls, Montana 59401

FOR: (Grower) Western Energy
Area A1 Stop 16 (Fa) Fort Collins

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
														LIME
9014		0-6	8.0	1.4	21.0		12.5	88	+35	15.9	0.3	0.4	L+	0
9015		6-12	7.9	1.1	6.25		7.7	188	7.5	6.6	0.1	0.2	SiCL-	0
9016		12-23	7.9	0.8	3.0		2.5	88	+35	8.0	0.1	0.4	L+	M+
9017		23-48	8.4	0.08	2.5		5.0	88	30.2	15.2	1.3	0.9	SiCL	M+
9018		48-72	7.9	0.08	14.0		17.5	88	32.8	12.6	2.8	0.4	SiL+	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis			Others
										% Clay	% Silt	% Sand	
								SAR					TEXTURE
2.06	0.3	10.0	1.8	14.4		17.08	8.54	0.46		28.8	34.4	40.4	L
0.7	0	11.2	1.8	11.4		17.24	8.62	0.27		28.8	52.4	18.8	SiCL
4.7	0	4.4	1.4	4.8		10.26	5.13	2.11		16.8	44.4	38.8	L
3.4	0	3.9	1.6	2.4		26.4	13.2	0.5		44.8	42.4	12.8	SiCL
0.7	0	4.4	1.4	3.2		6.7	3.35	1.62		10.8	50.4	38.8	SiL

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, I
P. O. Box 3013
Great Falls, Montana 59404

FOR: (Grower) Western Energy

Area 1A Ston 18 Ca Cushman

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Avail. H2O (Inche
9005		0-8	7.6	1.6	10.4		29.5	150	27.5	3.2	0.1	0.5	L	LIME M-
9006		8-15	7.7	1.1	4.5		12.5	113	32.4	3.8	0.1	0.4	L	M+
9007		15-30	8.0	0.08	1.25		2.5	62	9.5	8.5	0.1	0.4	L-	M+
9008		30-58	8.2	0.08	2.5		7.7	63	30.7	11.7	0.1	0.3	FSL	M+
9009		58-72	7.9	0.2	4.5		5.0	275	8.8	5.0	0.1	0.8	L-	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
1.4	0	5.5	1.8	10.8		10.93	5.47			17.8	6.4	75.8	SL
0.7	0	3.2	1.4	4.4		11.45	5.72			18.8	40.4	40.8	L
2.8	0	5.2	1.4	3.6		14.8	7.4			24.8	32.4	42.8	L
80.3	0	6.6	1.4	2.8		13.71	6.83			22.8	46.4	30.8	L
+138	0.3	4.4	1.1	1.8		15.4	7.7			25.8	15.4	58.8	SCL

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3043
Great Falls, Montana 59404

FOR: (Grower) Western Energy
Area A1 Stop 19 Ca Cushman

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
8999		0-6	6.5	0.08	1.85		5.0	350	18.5	5.0	0.3	0.4	L	LIME S
9000		6-8	6.7	0.08	0.25		7.7	238	21.1	5.3	0.1	0.4	L	S
9001		8-18	7.2	0.8	0.25		2.5	63	+35	4.5	0.1	0.4	L	M+
9002		18-24	7.6	0.08	0.25		17.5	88	33.3	4.8	0.1	0.3	FSL	M+
9003		24-38	7.7	0.08	0.5		2.5	2.5	+35	8.0	0.1	0.4	FSL	M+
9004		38-50	7.9	0.08	0.5		5.0	2.5	32.0	5.9	0.1	0.4	FSL	M+

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis			Others
										% Clay	% Silt	% Sand	Texture
0.7	0	6.6	1.6	13.8		13.71	6.85			22.8	20.4	56.8	SCL
4.1	0	11.5	1.6	9.2		10.16	5.08			16.8	30.4	62.8	SCL
0.7	0	7.8	1.4	5.4		14.89	7.44			24.8	28.4	56.8	SCL
0.7	0	6.3	1.4	2.8		10.16	5.08			16.6	6.8	78.6	SL
43.4	0	6.0	1.2	5.2		7.85	3.92			12.8	5.4	81.8	LS
59.4	0	10.0	1.1	13.1		10.16	5.08			16.8	6.4	78.8	SL

Ind.-Obs. 2570 5000

OVERBURDEN AND INTERBURDEN ANALYSIS AS RELATED TO REVEGETATION

Justification:

Undesirable soil characteristics such as high sodium (SAR), high salt, high percentage of clay, structures that cause very little water intake, and low fertility may inhibit reclamation. This soil analysis and the plant growth study were conducted to evaluate the potential reclamation problems that may occur from overburden and interburden materials.

Methods and Materials:

Two sets of samples were collected for each mining area by the Western Energy Company. Samples were taken at 12" increments until the coal was contacted. The samples were composited by depth according to the layers and related to the log that was provided by the Western Energy Company. Not more than 10 feet intervals were composited when the layer was almost the same throughout the interval. Occasionally, when the soil was sandy, samples from more than 10 feet were compiled. One set of samples, Area Pit #6 A10, was taken at 10 foot increments. Analysis and report were made accordingly.

Sample Preparation:

Samples were air dried and divided into two by taking alternate 6 inches of soil from each 12" tube. One half was kept in the plastic tube for future use and the other half was prepared for the complete soil analysis.

When necessary, samples were crushed to 1" by a jaw crusher, mixed and then divided into the following portions:

1. 500 grams for weathering and screen analysis wherever desired.
2. 500 grams screened (<9 mesh) for mechanical analysis.
3. Screen <12 mesh and divide into two - one half for greenhouse study and the other half for laboratory analysis.
4. Samples for laboratory analysis were screened to 20 mesh size. Samples designated for greenhouse could also be used for the weathering tests wherever desired.

5. 100 grams were sent to the U. S. Testing Lab for trace elements analysis.

6. For mechanical analysis, samples were screened to size 9 mesh.

Chemical Analysis

1. pH and conductivity - soil to solution of ratio 1:2.

2. Sodium Adsorption Ratio - (qualified by sodium content).

3. Sodium Exchange Potential - (calculate if necessary - CEC also). This has the same interpretation value as SAR.

4. Macro Analysis - organic matter, nitrate, phosphorous, potassium, calcium, magnesium, sodium, sulfur.

5. Micro Analysis - copper, iron, manganese, zinc, aluminum, barium, cadmium, lead, mercury, silicon, strontium, titanium, selenium, fluoride, molybdenum, arsenic, boron.

6. Soluble Salts.

7. CEC.

8. Mechanical Analysis.

9. Water Holding Capacity, at 0.33 bar and 15 bar suction (method developed by Gordon Decker "Automatic Retrieval and Analysis of Soil Characterization Data" PhD Thesis Montana State University, Bozeman, Montana, December 1972).

10. Plant Growth Tests.

a) 500 grams of air dry soil (or less if 500 grams of soil were not available).

b) Add 50 ppm P as concentrated super phosphate.

c) Add 50 ppm N as NH_4NO_3 on weekly basis.

d) Seeded to Winoda winter wheat 6 seeds/pot.

e) Water with distilled water to 0.33 bar or field capacity and weight maintained on daily basis.

f) Harvest - Report dry weight, tillers, and stand.

RESULTS AND DISCUSSION AREA A1:

Hole #N52E50 Lab No. 1595-1604 - A1-1

Hole #N51E53 Lab No. 1630-1637 - A1-2

Western Energy Company Test Hole Data: Drill Hole No. N51 E53

Prospect: Area A

Date: 9-12-73

Depth, feet	Formation Record	Depth Sample	Montana Testing Lab No.
0-54			
9-17	Light brown, fine grained sandstone	0-10 10-17	1630 1631
17-29	Gray sandstone & shale	17-29	1632
29-53	Light brown, fine grained sandstone	25-40 40-45 45-59 59-53	1633 1634 1635 1636
53-54	Gray sandstone & shale	53-54	1637

Chemical and Physical Analysis

1. pH - pH analyses were made for 2 sets of samples of Area A1 called A1-1 (N52E50) and A1-2 (N51E53). pH values are extremely high at some depths, exceeding a pH of 9. When pH exceeds 8.3 there is a possibility of sodium being present as indicated by the results of hole A1-2 (40-49').

Note: See sodium and SAR values and if sodium exceeds 4me/100 gm soil or SAR exceeds 10, there is some potential problem of high sodium concentrations.

2. Sodium Adsorption Ratio - Sodium adsorption ratio is associated with poor physical conditions of the soil. High values are associated with low water infiltration rates and for soils with values that exceed 10, it may become necessary to add gypsum prior to reclamation. The very high pH values could indicate high levels of SAR buth both holes in Area A1 had SAS levels less than 10. Hole number A1-1 indicates the presence of some salts and sodium throughout the profile but none too dramatically high. Hole number A1-1, depth 0.50', with SAR values 2.26 to 6.23 indicates the presence of some sodium. In sandy soils, however, even if SAR values exceed 10, there will be very little dispersion of sand particles to cause swelling that will lower hydraulic conductivity and water intake. Soils that contain very high percentage of

sand can tolerate higher levels of SAR and still maintain good soil physical properties. Both salt and exchangeable sodium could be leached out very easily if they are present in coarse textured soils that have good drainage. SAR values in A1-2 are very low.

The sandy characteristics are maintained in this hole except in layers 17-29' and 53-54'. The clay percentage seems to increase tremendously above the coal layer and can prevent water movement below that layer and consequently develops a reducing condition and increases the activity of some trace minerals. However, none of the trace minerals evaluated are at toxic level for plant growth. This clay layer should not be placed in the present texture and in the same depth in the "Backfill" operation. If possible, it should be mixed with the upper sandy material and placed at depths where water movement is anticipated. The clay in the soil will restrict water movement and possibly develop an aquifer and a "saline seep" problem may develop in the future years.

3. Sodium Exchange Potential - Not applicable for these soils since the SAR values are very low.

4. Macro Analysis - Organic Matter content is very low except in layers immediately above the coal seam where some of the mixed in coal is. Low organic matter concentrations may be the cause of some physical problems such as low hydraulic conductivity and water intake especially in soils high in clay percentage.

Nitrate-Nitrogen concentrations were very low throughout holes A1-1 and A1-2. Nitrogen is a very important factor in determining plant growth and supplemental nitrogen will be required if soils of these depths are utilized as top soils.

Phosphorous, Potassium, Calcium, Magnesium and Sulfur- phosphorous concentrations are considered very low at all depths. For revegetation, phosphorous should be supplemented in establishing a permanent cover. One or two applications per year for the first two years may be necessary.

Potassium content is considered low in hole A1-2 and medium in A1-1 throughout the profiles. If subsoil is mixed, it is very likely that supplemented potassium would be necessary in establishing a permanent cover.

Typically for most soils in Montana, calcium and magnesium remain at very high levels required for plant growth.

Sodium was reported with SAR values.

Sulfur is very high in both holes in Area A1 and if interburden material is used as top soil, supplemental sulfur will not be required.

5. Micro Analysis - Micro nutrients extractable in DTPA were not in deficient concentrations at any depth in both holes. No response to supplemental zinc, copper, iron and manganese are expected if interburden material is used as top soil.

6. Soluble Salts - High concentrations of soluble salts initiate early drought and unfavorable growth conditions. In Hole A1-2 concentrations of soluble salts are not high enough to prevent plant growth. In Hole A1-1 soluble salts are present throughout the depth but at levels acceptable to most plants. (Refer to U. S. Salinity Laboratory Handbook 60, 1954 for crop tolerance). Salt may be more concentrated in a narrow layer but were separated because of sample collection and preparation procedure.

7. Cation Exchange Capacity - Not applicable to these soils because SAR values were below 10.

8. Mechanical Analysis - Mechanical analysis is a measure of particle size distribution by percentage and presents guidelines for anticipating any physical problem.

Holes A1-1 and A1-2 at lower depths 64-69' and 53-54' contain layers of high percent clay. These layers should not be permitted to be placed on the surface. To prevent a layer of low hydraulic conductivity, it is desirable to mix some sandy material with this clay. Mixing with a coarse textured material will develop a better layer than is presently available. The mixture should be placed near the bottom of spoil material. The remaining texture for Area A looks very desirable.

9. Water Holding Capacity - 0.33 Bar and 15 Bar Suction - Water holding capacity is determined by imposing suctions of 0.33 and 15 bars. The amount of water held between these two suctions is normally expressed as Plant Available Water (PAW), and is primarily related to concentration of organic matter, amount of clay and structure.

Samples containing less clay will have the lowest amount of water at Field Capacity or 0.33 bar. As the clay content increases, the water holding capacity increases. Thus the amount of plant available water is normally related to the texture. As the quantity of fine particles increases, more water is held in the soil and aeration can restrict plant growth.

The water holding capacity was determined in two ways: (1) pressure membrane and (2) by the equation developed by Gordon Decker:

$$y = A + B_1X_1 + B_2X_2 \qquad \text{or}$$

$$y = 2.1 + 2.9 \text{ X \% clay} + .58\% \text{ O.M.}$$

10. Plant Growth Test - The plant growth test is in progress.

RECOMMENDATION:

1. From the chemical and physical analyses the Overburden and Interburden samples show very little potential problem that should restrict removal of soils for mining purposes. The physical properties may restrict growth because of high percentage clay that may cause low water intake. If the layers found in hole A1-1 and A1-2, at depths 64-69'and 53-54' are mixed as suggested previously, very little runoff and good permeability are anticipated and with good fertilized management, a good permanent cover will develop. Sandy materials may require special seeding practice because of low water holding capacity. Firm seedbeds and the use of mulch on the surface to prevent drying of surface soil and poor germination could be successful.

2. Application of gypsum has been shown to improve structure and improve water intake on high clay soils.

3. Caution must be used in sample collection and compositing layers. There is a possibility of inter-mixing layers that contain higher salt with layers with low salt and dilute the salt concentration of sodium.

4. From trace element analysis for overburden, Table 1 , it seems that the overburden does not contain unusual concentrations of these elements so to require special handling and replacement procedured beyond those due to other factors.

RESULTS AND DISCUSSION AREA E

Hole #N43-E69 Lab No. 1605-1614
Hole #N51-E61 Lab No. 1638-1651

Western Energy Company Test Hole Data: Drill Hole No. N43 E69

Prospect: Area E

Date: 9-12-73

Depth, feet	Formation Record	Sample Depth, ft.	Montana Testing Lab No.
0-69			
0-46	Light brown, fine grained sandstone	0-10	1605
		10-20	1606
		20-30	1607
		30-43	1608
		43-46	1609
46-69	Gray sandstone & shale	46-56	1610
		56-60	1611
		60-65	1612
		65-68	1613
		68-69	1614

Western Energy Company Test Hole Data: Drill Hole No. N51 #61

Prospect: Area E

Date: 9-13-73

Depth, feet	Formation Record	Sample Depth, ft.	Montana Testing Lab No.
0-36	Light brown fine grained	0-10	1638
		11-20	1639
		21-30	1640
		31-36	1641
36-38	Gray shale & sandstone	37-38	1642

38-47	Light brown fine grained	38-47	1643
47-53	Gray shale & sandstone	47-53	1644
53-56	Light brown fine grained sandstone	53-56	1645
		56-70	1656
56-91	Gray sandstone & shale	71-80	1647
		81-85	1648
		85-87	1649
		88-89	1650
		90-91	1650

Chemical and Physical Analyses

1. pH values in both holes are high and suggest the presence of sodium and/or toxic trace elements such as aluminum. (pH is used to predict excess iron or aluminum that may interfere with the availability of phosphorous and high sodium concentrations that may affect the water intake of the soil).

2. Sodium Adsorption Ratio (SAR) - Because pH values were high, SAR values were suspected to be high as well. However, ammonium acetate sodium concentrations were less than 0.3 me/100 gm of soil and SAR values were less than 2.0. No problem associated with sodium dispersion of soil particles causing low hydraulic conductivity and low water intake are anticipated.

3. Sodium Exchange Potential - Not applicable to these soils because the SAR values were very low.

4. Macro Analysis - Organic Matter was very low on all samples. Organic matter increases as it approaches the coal seam due to reasons given previously.

Nitrate-Nitrogen is very low at all depths.

Supplemental Nitrogen will be required.

Phosphorous, Potassium, Calcium, Magnessium, and Sulfur - Sodium bicarbonate extractable phosphorous is less than 1.0 ppm on all depths. This soil is very deficient in phosphorous and may require one or two annual applications for two years.

The available potassium is considered low in both holes in Area E. After mixing, it is very important that potassium become part of the fertilizer requirement in establishment of permanent cover.

Calcium and magnesium levels are well within the range found in Montana soils. No layer or depth indicate unusual concentration and should not present any growth establishment problem.

Sulfur is very high throughout the lower depth. If the lower depth (10') is to be mixed with the surface soil, additional sulfur may not be required. In this area it is suggested that only the upper 5 feet of top soil be stockpiled.

5. Micro Analysis - EDTA extractable - The micro nutrient extractable DTPA do not show deficiencies in any depth in both holes of Area E. The iron concentration increases in the layer where clay content is higher. The levels found in this layer will not cause any toxicity to plant growth but this layer should be separated from others as carefully as possible. The layer above this dense clay layer should be separated with caution.

No unusual amounts of other trace elements were found in these soils that would cause deficiency or toxicity to plant growth.

6. Soluble Salts - Soluble salts were low (less than 2 mmhos/cm) at all depths from the two holes taken in Area E. Very little salt problems are anticipated but if soil appears white, it is probably related to high sulfur sulfate in the profile.

7. CEC - Cation Exchange Capacity is not applicable to these soils.

8. Mechanical Analysis - Holes #N43E69 and #N51E61 contain a layer high in clay. It contains a clay loam layer at a depth of 43 to 46 feet. It is not a very dense clay layer but may restrict water intake. Hole #N51E61 contains a high percent clay layer that should not be permitted to be within the top 8' of soil. This layer is located at a depth of 48-53 feet. It is desirable that this clay layer be mixed with some coarse textured soil and be placed below 8 feet from the surface. Percent of clay could be reduced by intermixing layers that will cause changes in texture and composition.

The layer above the coal seam did not exhibit a high percent of clay (26.8%) and sodium and salt concentrations were very low.

9. Water Holding Capacity - The suction between 0.33 and 15 bars represents the amount of water held by the soil and available to the plant. The loamy sands and sandy loams will have low holding capacities while the clay loams and clays will exhibit very high water holding capacities.

10. Plant Growth Test - In progress. No plant growth problems associated with salt, sodium, or low hydraulic conductivity are anticipated from the layer that contains high clay content.

Report will be submitted separately when completed.

RECOMMENDATION:

1. The clay layer found in Hole #N51E61 should not be permitted to be placed near the surface. It is desirable to mix it with sandy soil and place it at lower depths.

2. Trace elements seem to increase as clay content increases. Careful sampling of all dense layers above it is recommended. It should be emphasized that two samples tested, Lab No. 1644 and 1651, Table 2, showed high levels of boron (6.3 ppm and 23.0 ppm, respectively). This should be checked for, and if levels >4.0 ppm are found in other locations during reclamation, those portions should not be replaced near the bed of the restored Rosebud aquifer (to prevent the chance of future leaching out) nor closer than 8 feet of the surface.

3. The parting layer did not have high levels of SAR or salt. Percent clay seems to be higher but will not lower hydraulic conductivity and water intake from the level found.

4. See stockpiling recommendations that accompany the soil descriptions.

RESULTS AND DISCUSSION PIT #6

Hole Station 118 Line 42

Hole Pit #6 A12

Hole Pit #6 A10

Hole Pit #6 A11

Western Energy Company Test Hole Data: Drill Hole No. Station 118 Line 42

Prospect: Pit # 6

Date: 9-12-73

Depth, feet	Formation Record	Depth Sample	Montana Testing Lab No.
0-128	plug		
0-104	Light brown, fine grained sandstone	0-10	1615
		10-20	1616
		20-30	1617
		30-40	1618
		40-50	1619
		50-60	1620
		60-70	1621
		70-80	1622
		80-90	1623
		90-104	1624
104-124	Gray sandstone & shale	104-114	1625
		114-120	1626
		120-124	1627
124-126		124-126	1628
126-128	Coal & gray shale mixed	126-128	1629

Discussion of Pit #6 will be limited to Hole 118 Line 42 due to similarity in analysis.

1. pH - pH values are high and suggest the presence of sodium.

2. Sodium Adsorption Ratio - Expected to be very low because of low concentrations of soluble sodium in such sandy soils.

3. Sodium Exchange - Not applicable to these soils.

4. Macro Analysis - Nitrogen, phosphorous, potassium and sulfur concentrations are expected to be very low. Supplemental fertilizer is very important in establishing seedlings.

5. Micro Nutrients - No response from supplemental trace minerals if subsoil is mixed with surface soil is expected.

6. Soluble Salts - Soluble salts concentrations (measured as conductivity) are very low throughout the depth. No injuries to germinating seedlings due to salt concentrations are anticipated.

7. CEC - Not applicable to these salts.

8. Mechanical Analysis - These soils contain very high percents of sand in all depths and are very desirable for water permeability, very little erosion, and plant support but will require frequent precipitation and one or two annual applications of fertilizers. Sandy soils may cause some germination problems due to rapid drying of the surface soil. Mulching with chopped straw is suggested to keep soil surface wet longer, initiate germination, and establish adequate stand.

Because of sandy nature, it is desirable if possible to mix with some loam or clay loam to increase clay content and improve water holding capacity.

9. Water Holding Capacity - In general, loamy sand and sandy loam make up most of the soil in this area and contain a very low percent of clay. Thus the water holding capacity of these soils is expected to be very low and require frequent precipitation for establishing grass seedlings.

10. Plant Growth Test - No germination and growth problems from soils in the area are expected.

RECOMMENDATION

1. Generally, coarse textured soils dominate this area, especially on the south end of Pit #6. Coarse textured soils are desirable for permeability and cause less erosion. Removal of the top soil in the south end of Pit #6 could be deeper than indicated previously. If adequate top soil is not available, it is desirable to remove sandy soil for stockpiling at deeper depths until raw material appears. (Stop 1 to 4). Stops 7 and 8 in Pit #6 are heavier soils (Heldt silty clay loam (refer to previous description) and top soil should be removed as suggested previously.

2. The parting layer did not contain high percentages of clay, salt, or high SAR values. The gray shale appears in the 104-114 feet depth, where the silt and clay content increases and thus should be kept at lower depths.

Deep Soil Analysis

Interburden and overburden analyses are contained in the following laboratory results.

Table 3

WESTERN ENERGY AREA A OVERBURDEN, MICRONUTRIENTS

Lab No	Depth (ft)	Ba	[illegible]	B	Ti	Mo	Sr	SiO_2	F	Water soluble F	Hg	Pb	Cd
1630	0-10	20.0	2.0	0.4	< 1	0.05	5.0	71.27	416	0.08	11.0	0.3	< .5
1631	10-17	17.5	2.0	0.3	< 1	0.09	6.0	68.6	328	2.36	11.0	0.5	0.5
1632	17-29	7.5	2.0	0.4	< 1	0.22	10.0	47.5	488	0.68	21.0	2.0	0.5
1633	29-40	5.0	2.0	0.4	< 1	0.11	7.0	62.98	560	0.64	18.0	0.5	0.5
1634	40-45	12.5	2.0	0.4	< 1	0.06	9.0	68.59	472	0.3	16.0	2.8	0.5
1635	45-49	12.5	1.0	0.5	< 1	0.08	7.0	71.71	320	0.4	13.0	0 6	0.5
1636	49-53	8.5	1.0	0.5	< 1	0.14	16.5	64.23	408	1.08	33.0	1.2	0.5
1637	53-54	8.5	1.0	1.4	< 1	0.07	40.5	46.05	384	0.02	86	2.0	0.5

Chemical analysis of core samples in ppm (except Hg in ppb)

WESTERN ENERGY AREA A OVERBURDEN, MICRONUTRIENTS (continued)

Lab No.	Depth	Ba	As	B	Ti	Mo	Sr	SiO_2	F	water sol.F	Hg	Pb	Cd	Al
1595	0-10	7.5	5.0	0.4	< 1	0.07	8.0		412	1.0	8.0	0.4	< .5	< 1
1596	10-20	3.5	3.0	0.6	< 1	0.12	8.5	18.77	416	1.24	15.0	0.3	< .5	< 1
1597	20-30	2.0	5.0	0.4	< 1	0.37	6.0	82,99	392	0.36	15.0	0.4	< .5	< 1
1598	30-40	≤ 2	6.0	0.2	< 1	0.13	7.0	47.3	368	0.44	15.0	0.4	< .5	< 1
1599	40-50	3.5	6.0	0.2	< 1	0.07	6.0	61.1	432	1.22	38.0	0.4	< .5	< 1
1600	50-62	2.0	4.0	0.1	< 1	0.17	7.0	48.39	440	0.68	30.0	0.4	< .5	< 1
1601	62-64	17.5	1.0	0.7	< 1	0.15	12.0	54,47	496	1.0	26.0	10.0	< .5	< 1
1602	64-66	2.0	1.0	0.5	< 1	0.31	23.5		472	0.95	43.0	2.6	< .5	< 1
1603	66-68	2.0	6.0	0.9	< 1	0.12	64.0	96,01	296	2.48	143	1.7	< .5	< 1
1604	68-69	2.0	2.0	0.7	< 1	0.12	59.0	64,11	340	1.48	140	1.6	< .5	< 1

Chemical analyses of core samples in ppm (except Hg in ppb) from overburden samples in Area A

WESTERN ENERGY AREA E OVERBURDEN, MICRONUTRIENTS

NW3 E69

Lab No.	Depth	Ba	As	B	Ti	Mo	Sr	SiO_2	F	water soluble F	Hg	Pb	Cd
1605	0-10	7.5	2.0	0.5	< 1	0.11	7.0	68.51	432	0.69	8.0	0.4	< .5
1606	10-20	20.0	1.0	0.5	< 1	0.14	8.5	56.64	432	0.44	13.0	0.4	0.5
1607	20-30	21.0	1.0	0.3	< 1	0.09	9.0	72.58	428	0.12	10.8	0.4	0.5
1608	30-43	7.5	2.0	0.3	< 1	0.12	9.0	67.71	408	0.24	19.0	0.3	0.5
1609	43-46	12.5	4.0	0.4	< 1	0.2	10.5	56.67	544	0.02	28.0	1.6	0.5
1610	46-56	7.0	1.0	0.6	< 1	0.22	8.5	53.88	496	0.44	23.0	1.4	0.5
1611	56-60	7.0	2.0	0.6	< 1	0.25	8.5	60.95	424	0.72	33.0	1.8	0.5
1612	60-65	2.0	1.0	0.5	< 1	0.14	5.5	72.2	424	0.5	25.0	0.11	0.5
1613	65-68	20.0	1.0	0.6	< 1	0.16	3.5	32.93	452	0.78	13.0	0.7	0.5
1614	68-69	< 2	1.0	1.0	< 1	1.17	3.5	61.47	332	0.86	10.0	0.6	0.5

WESTERN ENERGY AREA E OVERBURDEN, MICRONUTRIENTS (continued)

Lab No.	Depth	Ba	As	B	Ti	Mo	Sr	SiO_2	F	water sol. F	Hg	Pb	Cd	Al	Tot C
1638	0-10	17.5	5.0	0.4	< 1	0.07	7.0	58.36	416	0.72	12.0	0.3	< .5	< 1	
1639	11-20	11.0	2.0	0.5	< 1	0.12	5.0	64.13	0	0.44	8.0	0.3	< .5	< 1	45
1640	21-30	7.6	2.4	0.3	< 1	0.06	5.0	50.53	0	0.20	8.0	0.4	< .5	< 1	41
1641	31-36	5.0	3.5	0.3	< 1	.0.07	5.0	60.46	0	0.36	11.0	0.4	< .5	< 1	39
1642	37-38	5.0	1.0	0.4	< 1	0.22	8.5	44.49	0	0.84	20.0	0.8	< .5	< 1	60
1643	39-47	2.0	2.2	0.3	< 1	0.1	7.0	67.05	0	0.52	10.0	0.5	< .5	< 1	4
1644	48-53	5.0	1.5	5.3	< 1	0.19	10.0	33.13	0	0.52	20.0	1.6	< .5	< 1	6
1645	54-55	5.0	3.0	0.3	< 1	0.16	8.5	42.81	0	0.6	11.0	0.5	< .5	< 1	41
1646	57-70	2.0	2.0	0.4	< 1	0.22	6.0	57.65	464	0.3	16.0	0.5	< .5	< 1	
1647	71-80	5.0	< 1	0.4	< 1	0.32	6.0	65.63	408	0.24	13.0	0.4	< .5	< 1	
1648	81-85	3.5	1.1	0.2	< 1	0.22	6.0	49.3	0	0.4	8.0	0.8	< .5	< 1	4.
1649	85-87	2.0	1.6	0.2	1.5	0.22	7.0	44.27	0	0.24	7.0	0.9	< .5	< 1	3
1650	88-89	6.0	1.0	0.5	< 1	0.25	25.0	54.69	0	0.64	50.0	1.1	< .5	< 1	3
1651	90-91	5.0	2.0	23.0	< 1	0.1	66.0	59.45	0	1.64	9.0	1.9	1.0	< 1	3

Chemical analyses of core samples in ppm (except Hg in ppb) from overburden samples in Area E N51 E61

WESTERN ENERGY Pit #6 OVERBURDEN, MICRONUTRIENTS

Lab No.	Depth	Ba	As	B	Ti	Mo	Sr	SiO_2	F	water soluble F	Hg	Pb	Cd	Al
1615	0-10	7.5	1.0	0.2	< 1	0.06	6.0	65.12	480	0.36	13.0	0.3	< .5	< 1
1616	10-20	10.0	1.2	0.3	< 1	0.08	6.0	68.95	496	0.12	3.0	0.3	< .5	< 1
1617	20-30	15.0	1	0.4	< 1	0.08	7.0	76.3	368	0.12	22.0	0.4	< .5	< 1
1618	30-40	12.5	3.0	0.5	< 1	0 09	7.0	74.14	432	0.08	11.0	0.3	< .5	< 1
1619	40-50	7.0	1.0	0.3	< 1	0 09	6.0	69.29	428	0.24	10.0	0.2	< .5	< 1
1620	50-60	7.0	2.0	0.2	< 1	0.08	6 0	69.21	5.52	0 08	3.0	0.3	< .5	< 1
1621	60-70	11.0	1.5	0.2	< 1	0.07	6.0	33.84	472	0.36	13.0	0.3	< .5	< 1
1622	70-80	7.0	< 1	0.3	< 1	0.11	8.0	70 5	456	0.6	3.0	0.3	< .5	< 1
1623	80-90	7.0	1.2	0.3	< 1	0.11	6.0	33.9	500	0.24	10.0	0.3	< .5	< 1
1624	90-104	7.0	2.0	0.2	< 1	0.22	6.0	72.14	360	0.24	23.0	0.5	< .5	< 1
1625	104-114	5.0	< 1	0.3	< 1	0.25	5.5	39.17	464	0.36	22.0	0.8	< .5	< 1
1626	114-120	6.0	1.0	0.4	< 1	0.25	6.0	37.45	560	0.5	15.0	1.3	< .5	< 1
1627	120-124	5.0	< 1	0.5	< 1	0.25	5.0	66.25	5.4	0.5	15.0	0.8	0.5	< 1
1628	124-126	3.5	1.0	0.5	< 1	0.55	3.0	37.25	480	0.6	22.0	0.6	< .5	< 1
1629	126-128	7.5	< 1	1.4	< 1	1.2	9.0	63.6	340	0.86	24.0	0.8	0.5	1

Chemical analysis of core samples in ppm except Hg in ppb

Date Rec'd 9/ 73
Date Sent

RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Lal atori
P. O. Box 2013
Great Falls, Montana 59401

FOR: (Grower) Western Energy Co.
Area A Overburden

CLIENT: (Dealer)

Lab No.	Year Field No.	Depth	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture
1595		0-10	8.4	0.1	0.25		0.08	150	30.7	7.1	0.5	1.1	FSL+
1596		10-20	8.1	0.1	0.25		0.08	150	28.5	4.3	0.3	2.5	FSL
1597		20-30	8.3	0.1	0.25		0.08	150	18.5	3.0	0.3	1.3	FSL
1598		30-40	8.5	0.1	0.25		0.08	88	21.9	3.2	0.3	1.0	FSL
1599		40-50	8.0	0.1	0.25		0.08	113	10.0	2.7	0.1	2.7	FSL
1600		50-62	8.1	0.1	0.25		0.08	63	26.7	2.7	0.1	1.8	FSL
1601		62-64	8.2	0.9	0.25		0.08	113	25.5	4.3	0.3	1.9	L+
1602		64-65	7.9	0.4	0.25		0.50	150	21.1	8.9	0.1	1.3	SICL
1603		65-68	7.8	0.5	0.25		0.50	213	19.4	14.0	[illegible]	[illegible]	SICL-
1604		68-69	7.8	5.3	0.25		0.50	88	18.1	11.9	0.3	1.3	CL-

OTHER TESTS REQUIRED SAR

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	[illegible]	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Other
95 122.9	1.5	3.9	1.8	2.8		11.4	5.7	2.26		18.8	8.4	72.8	SL
96 +133	5.4	6.6	1.6	6.7		9.0	4.5	6.23		14.8	4.4	80.8	LS
97 95.6	18.1	6.3	0.9	8.2		6.6	3.3	4.47		10.8	2.4	86.8	LS
98 107.5	5.4	6.0	1.6	6.7		7.8	3.9	3.57		12.8	2.4	84.8	LS
99 +133	6.0	7.5	1.4	52		6.8	3.4	3.77		10.8	0.4	88.8	LS
00 +133	5.5	8.4	1.1	3.6		7.8	3.9	0.91		12.8	2.4	84.8	LS
01 +133	60.8	40.8	1.6	10.0		12.6	6.3	1.32		20.8	30.4	48.8	L
02 +133	61.3	55.0	2.9	5.2		26.44	13.22	1.01		44.8	22.4	32.8	C-
03 +133	72.5	30.6	4.8	4.2		24.16	12.08			40.8	24.4	34.8	C-
04 +133	40.6	30.0	5.6	3.2		20.58	10.29	0.63		32.8	18.4	48.8	SCL

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RESULTS OF
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Lab atories, Inc
P. O. Box 3043
Great Falls, Montana 59401

FOR: (Grower) Western Energy Co.
Area A Overburden

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
														LIME
1630		0-10	8.7	0.1	0.25		0.08	63	25.5	2.0	0.1	0.3	LS	M
1631		10-17	8.9	0.1	0.25		0.08	113	19.0	2.5	0.1	0.3	LS	M+
1632		17-29	8.7	0.1	0.25		0.08	113	+35	4.8	0.1	0.5	L+	V
1633		29-40	8.9	0.1	0.25		0.08	88	34.9	3.0	0.1	0.3	SL	M+
1634		40-45	9.1	0.1	0.25		0.08	63	29.4	2.5	0.1	0.3	VFSL	M
1635		45-49	9.2	0.1	0.25		0.08	88	32.4	2.5	0.1	0.3	VFSL	M
1636		49-53	8.7	0.1	0.25		0.08	63	17.3	4.8	0.1	0.6	VFSL+	M
1637		53-54	8.2	0.1	0.25		0.50	188	18.5	11.0	0.1	0.9	SiC	0

OTHER TESTS REQUIRED SAR

	Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	[illegible]	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	Mechanical Analysis % Silt	Mechanical Analysis % Sand	Others
0	6.1	1.5	21.2	1.2	3.4		6.8	3.4	0.32		10.8	0.4	88.8	LS-
1	13.8	1.2	4.4	1.4	10.8		7.8	3.9	0.09		12.8	2.4	84.8	LS
2	10.2	45.7	15.3	2.0	10.4		19.8	9.6			32.8	34.4	32.8	CL
3	9.9	1.8	10.6	1.4	11.1		9.0	4.5			14.8	26.4	58.8	SL
4	10.7	75.0	10.6	1.4	13.8		9.0	4.5	0.56		14.8	20.4	64.8	SL
5	2.8						9.0	4.5	0.34		14.8	4.4	80.8	SL-
6	16.2	13.1	13.5	2.0	8.0		16.0	8.0	0.79		26.8	4.4	68.8	SCL
7	51.7	10.6	17.0	3.2	7.4		26.4	13.2	0.45		44.8	14.4	40.8	C-

Date Rec'd. 9-1 3

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:

Montana Testing Lab tories, I
P. O. Box 3013
Great Falls, Montana 59401

FOR: (Grower) Western Energy Co.
Pit #6 Overburden

CLIENT: (Dealer)

Lab No.	Field No.	Depth	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Avail. H2O
		Feet												LIME
1615		0-10	9.1	0.1	0.25		0.50	88	33.3	3.2	0.1	0.3	LS	V-
1616		10-20	9.2	0.1	0.25		0.50	88	28.9	3.4	0.1	0.3	LFS	M
1617		20-30	9.4	0.1	0.25		0.08	63	19.8	3.2	0.1	0.3	LFS	M-
1618		30-40	7.8	0.1	0.25		0.08	113	21.9	2.7	0.1	0.3	LFS	M+
1619		40-50	7.9	0.1	1.25		0.50	88	32.8	2.5	0.1	0.2	LFS	M
1620		50-60	8.2	0.1	0.25		0.50	63	25.9	3.0	0.1	0.3	LFS	M
1621		60-70	8.4	0.1	0.25		0.50	63	21.5	3.0	0.1	0.2	LFS	S+
1622		70-80	8.3	0.1	0.25		0.80	63	23.3	3.0	0.1	0.3	LFS	M-
1623		80-90	8.4	0.1	0.25		0.50	88	22.8	2.7	0.1	0.3	S	M-
1624		90-104	8.5	0.1	0.25		0.50	88	+35	2.5	0.1	0.4	LFS	S+
1625		104-114	8.5	0.1	0.25		0.80	63	28.5	2.5	0.1	0.6	VFSL	M-
1626		114-120	8.7	0.1	1.85		0.50	88	26.7	3.0	0.1	0.5	SL	S
1627		120-124	8.8	0.1	0.25		0.50	63	21.5	2.7	0.1	0.4	VFSL+	S
1628		124-126	8.7	0.1	0.25		0.50	88	7.5	2.5	0.1	0.5	FSL	0
1629		126-128	8.1	5.6	0.25		0.08	63	11.8	5.3	0.1	0.8	SL	0

OTHER TESTS REQUIRED SAR

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	[illegible]	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
0.6	1.0	3.9	1.4	1.5		6.8	3.4	0.53		10.8	0.4	88.8	LS
2.1	2.0	5.2	1.1	2.8		6.8	3.4			10.8	0.4	88.8	LS
6.1	5.0	5.8	1.8	3.4		6.8	3.4			10.8	0.4	88.8	LS
7.0	0.9	6.3	1.4	3.2		6.8	3.4	0.67		10.8	2.4	86.8	LS
8.5	2.8	7.0	1.4	4.2		6.8	3.4			10.8	2.4	86.8	LS
7.0	2.5	5.8	1.2	4.0		6.8	3.4	0.97		10.8	3.4	85.8	LS
6.1	14.4	4.9	0.9	4.0		6.8	3.4	0.73		10.8	2.4	86.8	LS
7.4	1.5	5.5	1.4	4.0		7.8	3.9	0.63		12.8	4.4	82.8	LS
6.1	4.1	7.8	1.1	4.2		5.6	2.8	0.69		8.8	0.4	90.8	S
19.8	11.3	11.2	1.4	5.4		7.8	3.9	0.53		12.8	0.4	86.8	LS
47.9	23.6	30.0	1.8	6.4		11.4	5.7	0.56		18.8	38.4	42.8	L
26.4	8.8	21.2	1.8	4.4		7.8	3.9	0.66		12.8	4.4	82.8	LS
24.2	19.4	19.2	2.2	3.2		10.2	5.1	0.66		16.8	18.4	64.8	SL
[illegible]	6.0	[illegible]	1.4	3.4		7.8	3.9	0.48		[illegible]	10.4	[illegible]	SL
[illegible]	19.4	[illegible]	2.0	7.6		9.6	4.0	0.43		14.8	0.4	[illegible]	LS

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RESULTS
DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, I
P. O. Box [illegible]
Great Falls, Montana 59401

FOR: Western Energy Co.
(Grower)
Area E Overburden N 43 E 69

CLIENT:
(Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Avail. H2O
1605		0-10	8.6	0.1	0.5		0.08	88	28.9	3.8	0.1	0.4	LFS	M+
1606		10-20	9.0	0.1	0.5		0.08	113	30.7	4.6	0.1	0.4	FSL	V-
1607		20-30	8.9	0.1	0.25		0.08	113	21.1	3.0	0.1	0.3	LFS	M
1608		30-43	8.9	0.1	0.5		0.08	113	21.5	3.0	0.1	0.3	SL-	M+
1609		43-46	8.7	0.1	0.25		0.08	68	+35	4.8	0.1	0.5	L	M+
1610		46-56	8.8	0.3	0.25		0.08	113	20.9	3.4	0.1	0.4	L+	V
1611		56-60	8.7	1.3	0.25		0.08	88	24.5	3.4	0.1	0.6	L+	M+
1612		60-65	9.0	0.1	0.25		0.08	113	13.0	2.5	0.1	0.5	VFSL	M-
1613		65-68	8.8	0.1	0.25		0.08	113	3.3	2.7	0.3	0.6	FSL	0
1614		68-69	8.7	0.8	0.25		0.08	88	1.6	3.2	0.1	0.6	SL	0

OTHER TESTS REQUIRED

	Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	[illegible]	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
									SAR					
05	18.2	6.0	4.9	1.8	2.8		7.8	3.9	1.28		12.8	2.4	84.8	LS
06	7.4	20.6	21.2	1.0	8.6		9.0	4.5	0.92		14.8	8.4	76.8	SL
07	4.1	5.2	5.8	1.2	2.8		7.8	3.9	0.72		12.8	2.4	84.8	LS
08	7.0	8.8	10.2	1.4	8.0		6.8	3.4	0.86		10.8	0.4	88.8	LS
09	18.2	27.5	61.3	2.2	11.7		18.4	9.2	0.84		30.8	30.4	38.8	CL
10	11.3	59.4	47.5	2.3	5.8		14.84	7.42	0.84		24.8	16.4	58.8	SCL
11	73.7	2.6	21.5	2.3	4.4		16.2	8.1	0.59		26.8	34.4	38.8	L
12	34.4	9.4	12.8	1.3	1.8		7.8	3.9	0.60		12.8	14.4	72.8	SL
13	63.3	6.0	14.3	1.4	2.0		7.8	3.9	0.58		12.8	10.4	76.8	SL
14	55.0	3.7	13.8	3.2	2.4		9.1	4.55	0.58		14.8	0.4	84.8	LS

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DEEP SOIL SAMPLE ANALYSIS

P. O. Box 304
Great Falls, Montana 59401

FOR: Western Energy Co.
(Grower)
Area E Overburden E51 561

CLIENT:
(Dealer)

Lab No.	Your Field No.	Depth	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Avail.
1638		0-10	8.7	0.1	0.25		0.08	113	34.1	8.0	0.1	0.4	FSL+	M+
1639		11-20	8.6	0.1	0.25		0.80	213	25.5	4.1	0.1	0.3	LFS	M-
1640		21-30	8.7	0.1	0.25		0.08	2.5	19.4	3.4	0.1	0.3	LFS	M-
1641		31-36	8.6	0.1	0.25		0.08	63	25.9	3.2	0.1	0.4	LFS	M
1642		37-38	8.8	0.1	0.25		0.50	63	30.2	5.0	0.1	0.6	CL-	M+
1643		39-47	8.6	0.1	0.25		0.08	88	34.1	4.1	0.1	0.6	FSL+	M+
1644		48-53	8.7	0.1	0.25		0.08	113	28.9	3.4	0.1	0.8	CL+	V
1645		54-56	8.8	0.1	0.25		0.08	113	26.3	3.4	0.1	0.5	LFS	M
1646		57-70	8.5	0.1	0.25		0.08	113	23.6	2.2	0.1	0.8	LFS	M
1647		71-80	8.7	0.1	0.25		0.08	88	27.1	2.5	0.1	0.7	FSL	M+
1648		81-85	8.8	0.1	0.25		0.08	188	29.4	2.7	0.1	0.8	FSL+	M+
1649		86-87	8.8	0.1	1.25		0.08	113	28.9	2.5	0.1	0.7	L	M+
1650		88-89	8.7	0.8	0.25		0.08	63	32.0	6.2	0.1	0.9	L	M+
1651		90-91	8.2	5.7	0.5		0.08	113	32.4	7.6	0.1	0.9	L	M

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
0.6	1.3	4.0	1.8	3.6		15.5	7.75	0.49		25.8	6.4	68.8	SCL
0.6	0.6	4.9	1.2	5.2		7.96	3.98			12.8	4.4	82.8	LS
0.6	1.8	5.8	1.2	5.4		6.8	3.4			10.8	2.4	86.8	LS
22.0	2.6	6.0	1.6	6.1		6.8	3.4	0.39		10.8	2.4	86.8	LS
41.3	29.8	30.0	2.0	18.0		17.24	8.62	0.89		28.8	38.4	32.8	CL-
40.4	20.8	14.4	1.4	13.1		12.6	6.3	0.50		20.8	4.4	74.8	SCL-
44.0	6.0	57.5	2.5	12.4		26.2	13.2	0.61		44.8	16.4	38.8	C-
35.6	6.0	15.2	1.4	8.6		11.44	5.72	0.47		18.8	2.4	78.8	SL
47.9	12.5	21.4	1.4	4.2		9.0	4.5	0.38		14.8	0.4	84.8	LS+
40.4	3.8	27.8	4.8	3.2		9.0	4.5	0.39		14.8	0.4	84.8	LS+
50.3	56.9	28.8	2.6	3.4		10.28	5.14	2.6		16.8	2.4	80.8	SL
38.8	25.7	29.2	1.4	3.4		7.96	3.98	0.91		12.8	2.4	84.8	LS
59.4	25.7	19.0	2.0	2.8		17.2	8.6	1.7		28.8	2.4	68.8	SCL
47.9	16.9	24.6	5.3	6.2		16.02	8.01	1.85		26.8	2.4	70.8	SCL

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RESULTS OF DEEP SOIL SAMPLE ANALYSIS

Montana Testing Lab)tories, Inc.
P. O. Box 3013
Great Falls, Montana 59401

FOR: (Grower) Western Energy
Pit #6 A 10 Area E

CLIENT: (Dealer)

Lab No.	Your Field No.	Depth (Inches)	pH	Organic Matter %	Nitrate Nitrogen PPM	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O (Inches)
														LIME
9681		0-10	8.0	0.1	0.25		7.2	2.5	25.0	3.2	0.1	0.4	LFS	m
9682		10-20	8.5	0.1	0.25		6.4	2.5	28.0	3.8	0.3	0.3	LFS	M
9683		20-30	7.9	0.8	3.75		4.3	2.5	3.6	2.7	0.1	0.7	LFS	S-
9684	42.2-43.2		7.6	0.8	0.5		5.6	88	27.5	3.8	0.1	1.7	L-	M

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
								SAR					Texture
23.38	2.95	3.4	4.9	5.8				1.89					
23.38	1.5	6.3	3.0	4.0		6.8 5.4	3.4 2.7	0.49		10.8	0.4	88.8	S
+133	3.15	72	2.0	6.7		6.4	3.2	0.85		8.8	2.4	88.8	S
+133	5.75	6.0	4.2	14.0						10.8	58.4	30.8	SiL

Date Rec'd. 8-2?-73

Date Sent

RESULTS OF DEEP SOIL SAMPLE ANALYSIS

P. O. Box 3313
Great Falls, Montana 59404

I.D.: Western Energy
(Grower)
Pit #6 All Area E

CLIENT:
(Dealer)

Lab No.		Depth	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Avail. H₂O (Inch.)
														LIME
763		0-10	9.0	0.1	7.5		0.75	150	21.9	4.6	0.1	0.3	LFS	M
764		10-20	9.1	0.1	16.25		-0.5	150	27.5	4.8	0.3	0.3	LFS	M
0765		20-30	9.1	0.1	7.5		-0.5	150	33.7	5.0	0.1	0.3	LFS	M

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	Others
								SAR					
0.7	1.75	7.0	2.0	3.6				0.69					
0	0.90	6.3	1.8	3.6				0.43					
40.4	1.6	7.2	2.9	5.4				0.80					

Do Not Write In This Space

Date Rec'd. 8-27-73

Date Sent

RESULTS OF DEEP SOIL SAMPLE ANALYSIS

FROM:
Montana Testing Laboratories, Inc.
P. O. Box 3013
Great Falls, Montana 59404

FOR: (Grower) Western Energy
Pit #6 A 12 Area E

CLIENT: (Dealer)

Lab No.	Your Field No	Depth (inches)	pH	Organic Matter %	Nitrate Nitrogen ppm	Lbs./Ac. N	Phosphorus P ppm	Potassium K ppm	Calcium Ca meq/100g	Magnesium Mg meq/100g	Sodium Na meq/100g	Salt Hazards mmhos	Soil Texture	Available H2O LIME
9823		10	8.0	0.1	2.5		2.0	88	19.0	3.4	0.3	0.2	LFS	S
9824		20	7.5	0.5	0.5		1.8	88	17.7	3.6	1.0	1.7	LFS	M-
9825		30	8.5	0.1	0		1.8	63	20.6	1.8	0.5	0.4	LFS	M
9826		40	8.3	0.1	0		2.0	113	21.1	3.2	0.5	0.5	LFS	M
9827		50	8.5	0.1	0		2.8	63	20.6	2.4	0.5	0.3	LFS	M
9828		60	8.5	0.1	0		0.1	88	24.1	2.0	0.7	0.3	LFS	M
9829		70	8.2	0.1			0.1	88	5.75	3.2	0.3	1.1	VFSL-	S

OTHER TESTS REQUIRED

Sulfur ppm	Zinc ppm	Iron ppm	Copper ppm	Manganese ppm	Boron ppm	0.3 ATM	15 ATM	Lime or Gypsum	Cation Exchange Capacity (CEC)	Mechanical Analysis % Clay	% Silt	% Sand	~~XXXXXX~~ texture
21.5	0.85	5.5	1.8	7.0				SAR 1.63					
138	1.4	7.8	1.2	1.4									
49.2	1.5	8.0	1.4	4.2									
61	1.4	8.0	1.4	4.2									
26.4	2.4	8.4	1.2	6.4									
29.2	0.6	10.0	1.8	7.6									
+138	0.2	10.6	2.6	10.4				0.27					

26-2.10 (10) - 510300

2.(b) VEGETATION SURVEY

The ponderosa pine (*Pinus ponderosa*) forest, ponderosa pine savannah and central grasslands are the major natural vegetive types in the region around Colstrip, Montana. The ponderosa pine forest occurs at higher elevations near the study areas. Within the study areas the ponderosa pine is limited to rocky outcroppings and shallow rocky soils. The grassland communities generally contain six to eight major grass species, 25 forbs, and three to five shrub and half-shrub species.(1)

The vegetation on proposed mining sites A-1, Area E and Pit 6 has been classified by range vegetative association types (Volume 2) , with each type being characterized by two to four species (Appendix A - Species List), the first species listed usually being dominant or co-codominant with the other species. The vegetative types are listed and described for Site A-1 in Appendix B and for Area E and Pit 6 in Appendix C.

Climate is the overall dominating factor which limits vegetation distribution in the Colstrip area. While a grassland climate prevails, with very dry summers and most precipitation falling as rain from April through early July, ponderosa pine (*Pinus ponderosa* is able to persist on rocky uplands with special environments suitable for trees.

The most important vegetation types in the study area, based on size and productivity, are dominated by either needle-and-thread grass (Stipa comata), western wheatgrass (*Agropyron smithii*), or ponderosa pine. Bluebunch wheatgrass (*Agropyron spicatum*) was probably very important on drier sites in pre-settlement time. Locally dominant species are little bluestem (*Schizachrium scoparium*), prairie sandreedgrass (*Calamovilfa longigolia*), and sedges (*Carex spp.*).

Major local factors limiting the distribution of species are soil moisture availability, soil fertility or salinity, and land management practices. Vegetation types associated with the various soils of the area (Section 2 (a)) are listed in Table 4. Plant communities or vegetation types generally have homogeneity in structure and species composition and thus may be subjectively assigned boundaries. These boundaries or ecotones may be abrupt as a result of an abrupt discontinuity in environmental conditions or the ecotone may be a zone of gradual blending of two distinct factor complexes. A third transition type may be abrupt as a result of plant interactions such as competition, even through the environmental factor blending may be gradual. All three transitions can be recognized in the Colstrip study area.

In study areas A-1, E-1 and Pit 6 considerable environmental heterogeneity exists. Consequently much of the vegetation consists of ecotones or transitions among vegetative types. This is particularly true of the upland areas of A-1, where constant topographical changes influence soil types, exposure, and slope gradients. Rapid transitions from pine woodland to prairie occur, with constant intergrading of a variety of grassland types, usually reflecting gradients in soil moisture availability.

Soil moisture availability is a dominant factor in nearly all vegetative types indicated in the type maps of the study areas. Factors influencing soil moisture availability include soil parent material, soil texture, soil organic matter content, topography, slope exposure and solar influx, and soil permeability. Precipitation is relatively uniformly distributed over the study area, but depending on vegetative cover, soil type, and topography, moisture may be concentrated in stream channels, ponds, intermittent drainages, depressions, rocky porous soils, and in shaded ravines. Moisture is thus more available to plants adapted to these sites and both affects and effects species distributions.

Shrub species such as western snowberry (Symphoricarpos occidentalis) may only be found in moist drainages in the study area. This is also true of Kentucky bluegrass (Poa pratensis) and box elder (Acer negundo). Driest sites are dominated by drought tolerant species such as bluebunch wheatgrass, red threeawn (Aristida longiseta), and blue grama (Bouteloua gracilis). Sandstone ridges and rocky slopes bear ponderosa pine, whose long roots seek water trapped in rocky underground crevices. Western wheatgrass is commonly dominant in drainages and on less permeable soils where moisture may be concentrated.

Soil chemical properties occasionally markedly influence vegetation distribution in the Colstrip area. Colstrip soils are quite low in nitrogen and phosphorous, but some caprock buttes and eroded sites are very low in most major plant nutrients. Vegetation is very sparse under such conditions with only a few adapted species such as buckwheat (Eriogonum spp.) and rabbitbrush (Chrysothamnus spp.) capable of any permanence. Western wheatgrass is known for its tolerance of saline soil conditions and it is often found in lowland depressions and on heavy soils where salts accumulate.

Land management practices have greatly influenced vegetation distribution in the study area. Bluebunch wheatgrass, once dominant over a large portion of the study area, is generally present on upland sites less accessible to livestock or on sites where grazing pressure is limited by management and fencing. Sites grazed most heavily are invaded by shrubs and annual grasses. Sagebrush and sagewort (Artemisia spp.) are dominant or present on most sites subjected to moderate or heavy grazing. Cheatgrass (Bromus tectorum) and Japanese chess (Bromus japonicus) are abundant where perennial grass cover is sparse due to overgrazing. Broom snakeweed (Gutierrezia sarothrae) is an important invading half-shrub which, while occasionally present in good condition rangeland, may quickly become dominant on deteriorated rangeland.

Grazing affects and limits species distribution in a number of ways. Its primary influence is by selectively reducing vigor and competitive ability of palatable and desirable forage species, thus allowing increases in abundance of species which are less palatable or which have morphological or physiological characteristics which make them less susceptible to grazing damage.

The soil type on which a species is growing has a direct influence on the response of the plant to tissue removal. If the site is well within the tolerance limits of the plant or is optimum for its growth, the plant is less susceptible to grazing damage than if growing under marginal conditions. On deep sandy soils optimum for needle-and thread grass growth, it will persist under heavy grazing pressure that might eliminate it on any other soil type. Some grass species such as bluebunch wheatgrass, whose apical meristem is elevated, may decrease in abundance under grazing pressure regardless of habitat conditions.

When cultivated fields are abandoned in the study area, locally agressive species such as cheatgrass, Japanese chess, annual mustards, broom snakeweed, and sageworts and sagebrush quickly become dominant. Perennial grasses such as western wheatgrass and needle-and-thread grass appear in later successional seres. As propagules become available and as the site becomes modified by the vegetation produced, and depending on grazing influences, the site progresses toward the climatic and edaphic climax of pre-disturbance years.

SUMMARY

Climate and parent materials ultimately determine plant species distribution in the Colstrip area. Many complex and interrelated environmental factors influence distribution locally, with soil moisture availability, soil physical and chemical properties, and land use management considered dominant factors.

VEGETATION SURVEY MAPS

The Vegetation Survey maps are contained in Volume 2 of this Permit application.

LITERATURE CITED

1. Sindelar, B. W. 1973. Certain ecological analyses and information for study areas A, B, C, D, and E in the vicinity of Colstrip, MT. Westinghouse Electric Corp. 40 pp.

2. Choriki, R. 1973. Soil types in the Colstrip area. Unpubl.

Table 4

COMMON VEGETATION TYPES* ASSOCIATED WITH SOIL MAPPING UNITS **

	Associated Vegetation Types *	
Soil Map Symbol	Area E and Pit 6	A-1
Ca		Cu, 11
Da	11	
Ec	7, 9	8, 9, 10, 11, 12, 16, 17, 18
Eb	1, 2, 3, 4, 7, 6, 9	
El	17	10, 12
Fa		Cu
Ha	6, 11, 15	
Hu		14, 15
Ma		Cu, 6, 9, 14
Mb	1, 4, 5	Cu, 6, 24, 26
Mcc		Cu,
Mt		8, 9
Rb	8, 10, 11, 15	Cu, 1, 6, 13, 14, 21, 22, 23,
Rc		Cu, 2, 6,
Sa	9, 11, 16	2, 3, 4, 6, 7, 8, 10, 16, 17, 25, 26, 27,
Sb		16, 17
Ta		Cu, 24
Tb	4, 9, 11, 12, 16	Cu, 3, 5, 6, 9, 11, 13, 14, 15, 20, 23, 26
Tc	3, 4, 6, 8, 11, 13, 14	
U	9	

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* See Appedices A, B, C.

** See Vegetative Survey and Soil Maps and Acres Discription.

APPENDIX A - VEGETATION

SPECIES LIST WITH MAPPING SYMBOLS

Symbol	Scientific Names	Common Name
Grasses		
Agsm	*Agropyron smithii*	Western wheatgrass
Agsp	*Agropyron spicatum*	Bluebunch wheatgrass
Arlo	*Aristida longiseta*	Red threeawn
Bocu	*Bouteloua curtipendula*	Side oats grama
Bogr	*Bouteloua gracilis*	Blue grama
Brja	*Bromus japonicus*	Japanese brome
Brte	*Bromus tectorum*	Cheatgrass
Cael	*Carex eleochris*	Needleleaf sedge
Cafi	*Carex filifolia*	Threadleaf sedge
Calo	*Calamovilfa longifolia*	Prairie sandreedgrass
Caspp	*Carex spp.*	Sedge
Kocr	*Koeleria cristata*	Paririe junegrass
Mucu	*Muhlenbergia cuspidata*	Plains muhly
Orhy	*Oryzopsis hymenoides*	Indian ricegrass
Popr	*Poa pratensis*	Kentucky bluegrass
Pose	*Poa secunda*	Sandberg bluegrass
Scge	*Schizachrium gerardii*	Big bluestem
Scha	*Schizachrium hallii*	Turkeyfoot
Scsc	*Schizachrium scoparium*	Little bluestem
Spcr	*Sporobolus cryptandrus*	Sand dropseed
Stco	*Stipa comata*	Needle and threadgrass
Stvi	*Stipa viridula*	Green needlegrass

Symbol	Scientific Names	Common Name
Forbs		
Acmi	*Achillea millefolium*	Common yarrow
Amps	*Ambrosia psilostachya*	Western ragweed
Anpa	*Antennaria parvifolia*	Small-leaf pussytoes
Anro	*Antennaria rosea*	Rose pussytoes
Aspu	*Asclepias pumila*	Plains milkweed
Asca	*Aster campestris*	Aster
Ascr	*Astragalus crassicarpus*	Groundplum milkvetch
Cere	*Centaurea repens*	Russian knapweed
Ciun	*Cirsium undulatum*	Wavyleaf thistle
Civu	*Cirsium vulgare*	Blue thistle
Chvi	*Chrysopsis villosa*	Hairy golden aster
Ecpa	*Echinaceae pallida*	Purple coneflower
Erdi	*Erigeron divergens*	Wild daisy
Erst	*Erigeron strigosus*	Wild daisy
Eran	*Eriogonum annuum*	Annual eriogonum
Erspp	*Eriogonum spp.*	Buckwheat
Eula	*Eurotia lanata*	Winterfat
Getr	*Geum triflorum*	Prairie smoke
Glle	*Glycyrrhiza lepidota*	Wild licorice
Grsq	*Grindelia squarrosa*	Curlcup gumweed
Hebo	*Hedysarum boreale*	Northern sweetvetch
Lipu	*Liatris punctata*	Blazingstar
Lyju	*Lygodesmia juncea*	Skeletonweed
Mear	*Mentha arvensis*	Field mint
Meof	*Melilotus officinalis*	Yellow sweetclover
Oxspp	*Oxytropis spp*	Point vetch
Pepu	*Petalostemon purpureum*	Purple prairieclover
Phho	*Phlox hoodii*	Phlox
Plpu	*Plantago purshii*	Wooly plantain
Poal	*Polygala alba*	Milkwort
Pogl	*Potentilla glandulosa*	Cinquefoil
Pses	*Psoralea esculenta*	Prairie turnip

Symbol	Scientific Names	Common Name
Forbs (cont'd)		
Pste	*Psoralea tenuiflora*	Slimflower scurfpea
Raco	*Ratibida columnifera*	Prairie coneflower
Saka	*Salsola kali*	Russian thistle
Somi	*Solidago missouriensis*	Goldenrod
Sori	*Solidago rigida*	Goldenrod
Spco	*Sphaeralcea coccinea*	Scarlet globemallow
Taof	*Taraxacum officinale*	Dandelion
Trdu	*Tragopogon dubius*	Salsify
Shrubs and half-shrubs		
Arca	*Artemisia cana*	Silver sagebrush
Ardr	*Artemisia dracunculus*	Flase Tanagon sagewort
Arfr	*Artemisia frigida*	Fringed sagewort
Arlu	*Artemisia ludoviciana*	Sage
Artr	*Artemisia tridentata*	Big sagebrush
Chna	*Chrysothamnus nauseosus*	Rubber rabbitbrush
Chvi	*Chrysothamnus viscidiflorus*	Rabbitbrush
Crsu	*Crataegus succulenta*	Hawthorn
Gusa	*Gutierrezia sarothrae*	Broom snakeweed
Jusc	*Juniperus scopulorum*	Rocky Mountain Juniper
Opfr	*Opuntia fragilis*	Prickly pear
Oppo	*Opuntia polycantha*	Prickly pear
Prvi	*Prunus virginiana*	Chokecherry
Rhtr	*Rhas trilobata*	Skunkbrush sumac
Rispp	*Ribes spp.*	Currant
Rowo	*Rosa woodsii*	Wild rose
Syoc	*Symphoricarpos occidentalis*	Wolfberry
Yugl	*Yucca glauca*	Yucca

APPENDIX B - VEGETATION

VEGETATIVE TYPES IN AREA A1 WITH ASSOCIATED GRASSES, FORBS AND SHRUBS

Type 1 (Stco - Ardr) Stipa comata - Artemisia dracunculus

This site is a minor distrubed site with needle and thread grass being the dominant species.

Grasses	Forbs	Shrubs
Agsm*	Amps	Ardr
Bogr	Chvi	Arfr
Brja	Evan	Yugl
Brte	Erdi	
Cafi	Plpu	
Kocr	Pste	
Stco	Taof	
	Trdu	

Type 2 (Calo-Stco) Calamovilfa - Stipa comata

The soils in this type are sandy. The site is open and Prairie sandreedgrass and needle and threadgrass are the dominant species.

Grasses	Frobs	Shrubs
Agsm	Amps	Arcu
Bogr	Aspu	Arfr
Brja	Chvi	Arlu
Brte	Ciun	Opfr
Cafi	Ecpa	Rhtr
Calo	Eran	Rowo
Casp	Erdi	Yugl
Kocr	Glle	
Scha	Lipu	
Stco	Pste	
	Trdu	
	Sori	

Type 3 (Stco-Bogr-Cafi) *Stipa comata* - *Bouteloua gracilis* - *Carex filifolia*

The needle and threadgrass, blue grama and threadleaf sedge type is located on lower grassland slopes.

Grasses	Forbs	Shrubs
Agsm	Acmi	Arca
Agsp	Ciun	Ardr
Bogr	Erdi	Arfr
Brja	Grsq	Gusa
Brte	Lipu	Rowo
Cafi	Meof	
Calo	Pste	
Stco	Saka	
	Trdu	

Type 4 (Scsc-Stco) *Schizachrium scoparium* - *Stipa comata*

The site is a dry stone butte and the major species are little bluestem and needle and threadgrass.

Grasses	Forbs	Shrubs
Agsm	Amps	Ardr
Arlo	Asca	Arfr
Bocu	Asspp	Gusa
Bogr	Chvi	Yugl
Calo	Civu	
Popr	Ecpa	
Scsc	Meof	
Stco	Phho	
Stvi	Trdu	

Type 5 (Gusa-Bogr) *Gutierrezia sarothrae* - *Bouteloua gracilis*

Broom snakeweed has invaded this disturbed site. Blue grama is also present.

Grasses	Forbs	Shrubs
Agsm	Amps	Ardr
Bogr	Chvi	Arfr
Boqr	Ciun	Gusa
Brte	Eran	
Cafi	Erdi	
Kocr	Pste	
	Somi	

Type 6 (Stco-Stvi-Kocr) *Stipa comata* - *Stipa viridula* - *Koeleria cristata*

The needle and threadgrass, green needlegrass and prairie junegrass type is a protected grassland.

Grasses	Forbs	Shrubs
Agsm	Amps	Ardr
Arlo	Eran	Arfr
Bogr	Lipu	Gusa
Brja	Somi	Rhtr
Brte	Sori	Yugl
Cael	Trdu	
Calo		
Caspp		
Kocr		
Popr		
Scge		
Scsc		
Stco		
Stvi		

Type 7 (Pips-Stco-Bogr) *Pinus ponderosa* - *Stipa comata* - *Bouteloua gracilis*

The overstory is ponderosa pine with needle and threadgrass and blue grama. The sites are dry, rocky knolls.

Grasses	Forbs	Shrubs
Agsm	Asspp	Ardr
Agsp	Chui	Arfr
Arlo	Civu	Arlu
Bocu	Ecpa	Artr
Bogr	Lipu	Chna
Cafi	Phho	Gusa
Kocr	Pste	Jusc
Mucu	Sori	Rhtr
Scsc		Yugl
Stco		

Type 8 (Pipo-Agsp-Cafi) *Pinus ponderosa* - *Agropyon spicatum* - *Carex filifolia*

This type is found on damp hillsides and draws with ponderosa pine, bluebunch wheatgrass and threadleaf sedge being the dominant species.

Grasses	Forbs	Shrubs
Agsm	Acmi	Arca
Agsp	Getc	Arfr
Arlo	Glle	Arlu
Bocu	Grsq	Chna
Cafi	Oppo	Gusa
Calo	Pepu	Jusc
Kocr	Raco	Rhtr
Popr	Sori	Rowo
Stvi	Trdu	Syoc

Type 9 (Agsm-Popr-Arspp) *Agropyron smithii* - *Poa pratensis* - *Artemisia spp*.

Western wheatgrass, Kentucky bluegrass and several species of sagebrush are located in damp draws and ravines.

Grasses	Forbs	Shrubs
Agsm	Acmi	Arfr
Agsp	Chvi	Arlu
Arlo	Ecpa	Gusa
Bogr	Erst	Rhtr
Brja	Glle	Rowo
Brte	Grsq	Syoc
Cafi	Oppo	
Kocr	Pste	
Popr	Raco	
Pose	Somi	
Stco	Sori	
Stvi	Taof	
	Trdu	

Type 10 (Artr-Bogr-Stco) *Artemisia tridentata* - *Bouteloua gracilis* - *Stipa comata*.

This type is located on dry upland grasslands. The dominant species are big sagebrush, blue grama and needle and threadgrass.

Grasses	Forbs	Shrubs
Agsm	Anpa	Arfr
Agsp	Asca	Gusa
Arlo	Chui	Rhtr
Bogr	Ecpa	Yugl
Cafi	Erspp	
Kocr	Grsq	
Mucu	Lipu	
Stco	Phho	
	Pste	
	Trdu	

Type 11 (Agsp-Cafi-Agsm) *Agropyron spicatum* - *Carex filifolia* - *Agropyron smithii*

The wheatgrasses, western and bluebunch, in association with threaded sedge dominates this type found on lower open slopes.

Grasses	Forbs	Shrubs
Agsm	Chvi	Arca
Agsp	Popu	Ardr
Arlo	Pste	Arfr
Bogr	Sori	Arlu
Brja	Trdu	Artr
Brte		Gusa
Cael		Rhtr
Cafi		Yugl
Pase		
Stco		
Stvi		

Type 12 (Agsm-Kocr) *Agropyron smithii* - *Koeleria cristata*

Type 12 is located on open grassy slopes with deep soil. The major species are western wheatgrass and prairie junegrass.

Grasses	Forbs	Shrubs
Agsm	Lyju	Arfr
Arlo	Plpu	
Brja	Spco	
Brte	Taof	
Cafi	Trdu	
Kocr		

Type 13 (Agsm-Popr-Arca) *Agropyron smithii* - *Poa pratensis* - *Artemisia cana*

Many shrubs are present on this type. The site is open draws and the major species are western wheatgrass, Kentucky bluegrass and silver sagebrush.

Grasses	Forbs	Shrubs
Agsm	Raco	Crsu
Arlo	Asca	Ardr
Stco	Pogl	Arca
Kocr	Acmi	Prvi
Stvi	Amps	Syoc
Popr	Taof	Rowo
Brte	Mear	
Brja		
Calo		

Type 18 (Stco - Cafi - Mucu) *Stipa comata* - *Carex filifolia* - *Muhlenbergia cuspidata*.

The needle and threadgrass, threadleaf sedge and plains muhly type is located on open grassy ridges.

Grasses	Forbs	Shrubs
Kocr	Eran	Arlu
Scsc	Chui	Artr
Cafi	Trdu	Rowo
Mucu	ecpa	Arfr
Brte	Asca	Arca
Brja		Ardr
Calo		Yugl
Agsm		
Arlo		

Type 19 (Bogr - Arlo - Agsp) *Bonteloua gracilis* - *Aristida longiseta* - *Agropyron spicatum*.

The site for type 19 is open north slopes. The major species are blue grama, red threeawn and bluebunch, wheatgrass.

Grasses	Forbs	Shrubs
Agsp	Oppo	Arfr
Arlo	Acmi	Gusa
Bogr	Taof	Artr
Stco	Spco	Rhtr
Pose	Trdu	
Kocr	Erdi	
Brte	Phho	
Brja	Chui	
Agsm		
Cafi		

Type 16 (Pipo - Agsp - Bogr) *Pinus ponderosa* - *Agropyron spicatum* - *Bouteloua gracilis.*

Type 16 is located on dry steep slopes and clay brittes. Ponderosa pine occurs with bluebunch wheatgrass blue grama.

Grasses	Forbs	Shrubs
Agsm	Trde	Ardr
Agsp	Chui	Arfr
Stco	Ciun	Gusa
Stui	Lipu	Rhte
Bogr	Anro	Jusc
Calo	Erspp.	Yugl
Cafi	Asspp.	Rowo
Scsc		Chna
		Artr

Type 17 (Pipo - Agsp - Scsc) *Pinus ponderosa* - *Agropyron spicatum* *Schizachrium scoparium*

Wooded uplands of ponderosa pine with bluebunch wheatgrass and little bluestem makeup type 17.

Grasses	Forbs	Shrubs
Agsm	As spp.	Gusa
Agsp	Ecpa	Arfr
Arlo	Sori	Rhtr
Kocr	Somi	Ardr
Bogr	Asca	Rowo
Brte	Pepu	Chna
Brja		Jusc
Scsc		
Calo		
Bocu		
Stco		

Type 20 (Kocr - Stco - Cafi) Koeleria cristata - Stipa Comata - Carex filifolia.

The prairie junegrass, needle and threadgrass and threadleaf sedge type is located on an ungrazed lowland knoll.

Grasses	Forbs	Shrubs
Stco	Eran	Yugl
Cufi	Sori	Arfr
Kocr	Lipu	Rhtr
Pose	Lyju	Rowo
Popr	Spco	
Cael	Amps	
Brte	Somi	
Brja	Pepu	
Agsm	Trdu	
Calo	Chvi	
Scha	Asca	
Mucu	Opfr	
	Erdi	

Type 21 (STco - Kocr) Stipa comata - Koeleria cristata

Type 21 is an ungrazed minor but unique grassland type. The major species are needle and threadgrass and prairie junegrass.

Grasses	Forbs	Shrubs
Brte	Amps	Rowo
Brja	Chui	Yugl
Pose	Trdu	Syol
Popr	Eran	Arfr
Stco	Ciun	
Kocr		
Agsm		
Cafi		
Cael		

Type 22 (Arca - Caspp - Ardr) Artemisia cana - Carex species - Artemisia dracinculus.

The silver sagebrush, sedge and false taragon sagewort type is a minor shrub type.

Grasses	Forbs	Shrubs
Caspp	Amps	Rowo
Popr	Pste	Arlu
Stco	Sori	Ardr
Brte	Taof	Arca
Brja		
Agsm		
Kocr		
Pose		
Calo		

Type 23 (Ardr - Caspp) Artemisia dracunculus - Carex species

This type is a minor shrub type. The dominant species are false taragon, sagewort and sedge.

Grasses	Forbs	Shrubs
Caspp	Taof	Arfr
Bogr	Lipu	Ardr
Brte	Amps	
Brja	Eran	
Stco		
Cafi		
Popr		

Type 24 (Agsm - Brte - Brja) Agropyron smithii - Bromus tectorum - Bromus japonicus.

The western wheatgrass , Japanese brome - cheatgrass type occurs on old cultivated fields.

Grasses	Forbs	Shrubs
Aqsm	Trdu	Arca
Brte	Taof	Ardr
Brja	Acmi	
	Erdi	

Type 25 (Agsp - Scsc) Agropyran spicatum - Schizachruim scoparium

Bluebunch, wheatgrass and little bluestem are the major species on this type which occur on a scoria brittle.

Grasses	Forbs	Shrubs
Aqsp	Ecpa	Gusa
Scsc	Lipi	Yugl
Mucu	Phho	Arfr
	Trdu	Rhtr

Type 26 (Stco - Caspp) Stipa camata - Carex species

Type 26 occurs on open east facing slopes. Needle and threadgrass and sedges dominate the type.

Grasses	Forbs	Shrubs
Caspp	Trdu	Arca
Brte	Ecpa	Arfe
Brja	Taof	Ardr
Kocr	Raco	Gusa
Aqsm	Acmi	
Stui	Opfr	
Arlo		
Stco		

Type 27 (Stco - Scsc) *Stipa comata* - *Schizachrium scoparium*

This type occurs on little used east slopes. Needle and threadgrass and little bluestem are the major species.

Grasses	Forbs	Shrubs
Stco	Trdu	
Calo	Amps	Yugl
Scsc	Lipu	
Brte	Erdi	
Brja	Taof	
Agsm		
Kocr		
Cafi		

Cultivated

The croplands are usually strip farmed with alternate strips of summer fallowed and seeded ground. Winter sheat, barley, oats and alfalfa grass bay are the common crops produced.

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*See Appendix A.

APPENDIX C - VEGETATION

VEGETATIVE TYPES IN AREAS E1 AND PIT 6 WITH ASSOCIATED GRASSES, BORBS AND SHRUBS

Type 1 (Artr - Agsp) Artemisia tridentata - Agropyron spicatum

This is a major type occuring on these sites. The type is found on slightly sloping eroded areas. The big sagebrush is dense in some places with considerable open bare ground with minimal litter cover.

Grasses	Forbs	Shrubs and Halt-Shrubs
Agsm*	Acmi	Arfr
Agsp	Cere	Artr
Brte	Eula	Gusa
Brja	Meof	
Kocr	Taof	
Pose	Trdu	
Stvi		
Bogr		

Type 2 (Stco - Gusa) Stipa comata - Gutierrezia sarothrae

Type 2 is another major type with needle and threadgrass the dominate species. This type occurs on slightly sloping, slightly stony area.

Grasses	Forbs	Shrubs and Halt-shrubs
Boyr	Lipu	Artr
Agsm	Ciun	Arfr
Mucu	Somi	
Kocr	Grsq	

Type 3 (Stco - Cafi - Bogr) *Stipa comata* - *Carex filifolia* - *Bouteloua gracilis*

The needle and threadgrass, threadleaf sedge and blue grama type is in good condition with moderate litter. This type occur on slightly sloping sites.

Grasses	Forbs	Shrubs
Bogr	Chvi	Ardr
Cafi	Meof	Arfr
Brte	Eran	Gusa
Brja	Amps	Yugl
Calo	Cere	Artr
Pose	Cien	
Stco	Poal	
	Oxspp	
	Somi	

Type 4 (Stco - Arsr - Yugl) *Stipa comata* - *Artemisia frigida* - *Yucca glauca*

Type 4 occurs as a major type on slopes. The major species are needle and threadgrass, fringed sagewort and yucca.

Grasses	Forbs	Shrubs
Agsm	Meof	Rhtr
Bogr	Trdu	Arfr
Brja	Taof	Ardr
Brte	Amps	Yugl
Cafi	Chvi	Gusa
Scsc	Spco	Artr
Stco	Pses	
Stvi	Lyju	
Spor	Ciun	
	Eran	

Type 5 (Stco - Argr - Arspp) *Stipa comata* - *Artemisia frigida* - *Artemisia species*.

Similar to type 4 but includes a dense stand of silver sagebrush and big sagebrush.

Type 6 (Agsm - Gusa - Stco) *Agropyron smithii* - *Gutierrezia sarothrae* - *Stipa comata*.

The dominant species on this type are western wheatgrass, broom snakeweed and needle and threadgrass.

Grasses	Forbs	Shrubs
Agsm	Ecpa	Arca
Bogr	Asca	Arfr
Brja	Chvi	Artr
Brte	Meof	Yugl
Calo	Acmi	Gusa
Kocr	Amps	Arlu
Stvi	Erdi	
Stco	Spcu	
Popr	Raco	
Agsp	Trdu	
	Poal	
	Glle	
	Phho	
	Taof	
	Ciun	

Type 7 (Pipo - Scsc - Stco) *Pinus ponderosa* - *Schizachrium scoparium* - *Stipa comata*.

Type 7 occurs on dry buttes with scattered ponderosa pine as overstory. Little bluestem and needle and threadgrass occur as the major grass species.

Grasses	Forbs	Shrubs
Agsp	Phho	Ardr
Agsm	Pepu	Gusa
Cafi	Lipu	Rhtr
Calo	Erdi	Chna
Mucu	Asca	Rowo
Orhy		Yugl
Scsc		
Stco		

Type 8 (Agsm - Gusa - Popr) *Agropyron smithii* - *Gutierrezia sarothrae*- *Poa pratensis*.

The western wheatgrass - broom snakeweed - Kentucky bluegrass type occurs in an old field.

Grasses	Forbs	Shrubs
Agsm	Acmi	Arfe
Brte	Neof	Chvic
Brja	Erdi	Gusa
Bogr	Taof	Arca
Kocr	Trdu	
Popr		
Stco		
Stvi		

Type 9 (Pipo - Agsp - Stco) *Pinus ponderosa* - *Agropyron spicatum* - *Stipa comata*.

Ponderosa pine is the dominant species of these wooded hills. The major grass species are bluebunch, wheatgrass and needle and threadgrass.

Grasses	Forbs	Shrubs
Agsp	Pepu	Jusc
Bogr	Anro	Gusa
Bocu	Anpa	Arfr
Calo	Amps	Rhtr
Kocr		Arca
Stvi		Yugl
Scsc		
Stco		

Type 10 (Artr - Stco - Agsm) *Artemisia tridentata* - *Stipa comata* - *Agropgron smithii*.

Type 10 occurs in damp draws and gulleys. The dominant species are big sagebrush needle and threadgrass and western wheatgrass.

Grasses	Forbs	Shrubs
Agsm		Artr
Bogr	Eran	Arca
Cafi	Taof	Arfr
Brte	Trdu	Gusa
Brja		Ardr
Arlo		

Type 11 (Stco - Yugl - Calo) Stipa comata - Yucca glauca - Calamovilfa longifolia.

This is a major type on open slopes. The major species are needle and threadgrass, yucca and prairie sandreedgrass.

Grasses	Forbs	Shrubs
Bogr	Amps	Yugl
Kocr	Lipu	Rhtr
Brte	Chvi	Ardr
Cael	Pste	Gusa
Scsc	Eran	
Calo	Somi	
Stco	Opfr	
Cafi	Raco	
Scha	Pses	
Scge	Trdu	
	Ciun	

Type 12 (Agsp - Gusa) Agropyron spicatum - Gutierrezia sarothrae

Type 12 is unique type on lower north facing slopes. Bluebunch, wheatgrass and broom snakeweed dominate this type.

Grasses	Forbs	Shrubs
Agsp	Ecpa	Gusa
Agsm	Meof	Artr
Cael	Phho	
Cafi	Trdu	
Royr	Eula	
Pose		
Kocr		
Stco		

Type 13 (Agsm - Stvi - Artr - Ca i) Agropyron smithii - Stipa viridula - Artemisia tridentata - Carex filifolia.

This type occurs on a formerly cultivated field. The four dominant species are western wheatgrass, green needlegrass, big sagebrush and threadleaf sedge.

Grasses	Forbs	Shrubs
Agsm	Taof	Artr
Brte	Meof	Arfr
Brja		Ardr
Kocr		Arlu
Cafl		Arca
Stvi		

Type 14 (Cafi - Gusa - Stco) Carex filifolia - Gutierrezia sarothrae - Stipa comata

Type 14 occurs on a lightly grazed knoll. Threadleaf sedge, broom snakeweed and needle and threadgrass dominate the type.

Grasses	Forbs	Shrubs
Agsp	Amps	Jusc
Stco	Chvi	Rowo
Cafi	Ciun	Rhtr
Bogr	Trdu	Yugl
Scsc	Meof	Arfr
Calo	Eran	

Type 15 (Bogr - Euta - Gusa) Bouteloua gracilis - Eurotialanata - Gutierrezia Sarothrae.

This minor type is nearly an exclusive blue grama community with same winterfat and broom snakeweed.

Grasses	Forbs	Shrubs
Bogr	Erst	Ardr
Brte	Trdu	
Brja	Eula	
Stco		
Agsm		

Type 16 (Pipo - Rock) Pinus ponderosa - Rock

Occurs on sandstone outcrops with highly varied species, but is similar to Type 9.

Type 17 (Pipo - Agsp - Cafi) Pinus ponderosa - Agropyron spicatum - Carex filifolia.

These ponderosa pine wooded uplands have bluebunch, wheatgrass and threadleaf sedge as the dominant grass species.

Grasses	Forbs	Shrubs	
Agsp	Getr	Jusc	
Cafi	Sori	Rhtr	
Arlo	Acmi	Yugl	Oppo
Calo	Pepu	Rowo	
Kocr	Grsq	Arca	
Bocu	Glle	Chna	
Aqsm	Raco	Arfr	
Stvi	Trdr	Arlu	
		Gusa	

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*See appendix A.

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2.(c) WILDLIFE SURVEY

The wildlife within the proposed mining locations, Area E, Pit 6 and A-1, is typical of the eastern portion of Montana. The habitat, also characteristic of this region, consists of ponderosa pine, grassland and sagebrush. The variety of ecosystems provides for an assortment of faunal components.

A number of game animals are present within the areas being considered in this report. Equally as important, from an ecological view, are the other elements of the faunal system. Included among these are the non-game species of birds, small mammals, reptiles and amphibians. The areas are used throughout the year by most species except those which are migratory. The basic sources of faunal information for this section were two wildlife reports made on the area around Colstrip(1,2) and supplemental information on sites A-1, Area E and Pit 6.(7) Wildlife maps show observation routes on the areas concerned. Tables 5, 6 and 7 present observation data for the three areas, A-1, Area E and Pit 6, respectively. Table 8 is a list of animals and birds of the Colstrip area. These species are known to occur on the three study areas. Wildlife survey maps are in Volume 2.

Table 5

WILDLIFE OBSERVATIONS ON AREA A-1 (7)

Species Game Animals	Date of Observed	Number Observed	Location	Type of Transect	Vegetation
Mule Deer	7/7/73 (05:55)	1 Female	NW.Sect. 32 2N41E	Vehicle	Ponderosa pine
Antelope	4/13/73 (17:45)	1 Male	NW.Sect. 16 1N41E	Vehicle	Rhus-grass
	6/6/73 (21:00)	3 Females		Air	Grassland
	6/6/73 (20:45)	1 Male/2 Females	1N41E	Air	Rhus-grass
	9/25/73 (08:10)	1 Male/12 Females/ 5 Fawns	1N41E	Air	
Sharptail grouse	8/2/73 (1900)	3 immature	NW.Sect. 5 1N41E	Vehicle	
Pheasant	8/3/73 (13:30)	7 immature	NW.Sect. 5 1N41E	Vehicle	Armells Creek Bottom (riparian zone)
Hungarian partridge	9/17/73 (13:10)	7 immature	SW. Sect. 5 1N41E	Vehicle	
Small Animals					
Peromyscus maniculatus	5/10/73-5/17/73	6	SW. 1/4 Sect. 4 1N41E	Trap	Armells Creek Bottom (riparian zone)
Microtus orhhogaster	5/9/73-5/13/73	1	SW. 1/4 Sect. 4 1N41E	Trap	
Peromyscus maniculatus	9/13/73-9/17/73	6	NW. 1/4 of NE 1/4 Sect. 32, 2N41E	Trap	Ponderosa pine
Peromyscus maniculatus	9/21/73-9/25/73	6	SW. 1/4 of SW. 1/4 Sect. 33, 2N41E	Trap	Grassland
Peromyscus maniculatus	9/21/73-9/25/73-9/25/73	13	SW. 1/4 of SW. 1/4 Sect. 33, 2N41E	Trap	Rhus-grassland

Table 6

WILDLIFE OBSERVATIONS IN AREA E(7)

Species	Date of Observation	Number Observed	Location	Type of Transect	Vegetation
Mule Deer	7/8/73 (06:20)	1 Male	NE. 1/4 of Sect. 3, 1N41E	Vehicle	Silver Sagebrush grassland
	7/19/73 (o7:40)	1 Male/1 Female	SW. 1/4 of Sect. 2, 1N41E	Vehicle	Rhus-grasslands
	7/21/73 (13:50)	1 Male	SW. 1/4 of Sect. 2, 1N41E	Vehicle	Rhus-grasslands
Sharptail Grouse	7/19/73 (19:15)	2 Immature	SE. 1/4 of Sect. 3, 1N41E	Vehicle	Silver Sagebrush grassland
Pheasant	3/21/73 (06:50)	1 Male	SE, 1/4 of Sect. 3, 1N41E	Vehicle	Grasslands

Table 7

WILDLIFE OBSERVATIONS IN PIT 6 AREA*

Date	Time	Observation
9-14-71	7:05 AM	Golden eagle on ground
9-15-71	8:05 AM	1 male and 18 female antelope
9-21-71	8:18 AM	1 male and 9 female antelope
10-30-71	9:00 AM	2 golden eagles feeding on dead antelope
11- 5-71	9:00 AM	3 unclassified sharptail grouse
12-14-71	-- AM	1 red fox

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*Observations by J.D. Sindelar

Table 8

COMMON ANIMALS AND BIRDS OF COLSTRIP AREA (1,2,7)

	Common Name	Scientific Name
MAMMALS:	Badger	*Taxidea taxus*
	Bobcat	*Lynx rufus*
	Coyote	*Canis latrans*
	Deer Mouse	*Peromyscus maniculatus*
	Desert cottontail	*Sylvilagus audubonni*
	Least chipmunk	*Eutamias minimus*
	Longtail weasel	*Mustela frenata*
	Mule deer	*Odocoileus hemionus*
	Muskrat	*Ondatra zibethicus*
	Porcupine	*Erethizon dorsatum*
	Prairie dog	*Cynomys lucovicianus*
	Prairie vole	*Microtus ochrogaster*
	Pronghorn antelope	*Antilocapra americana*
	Raccoon	*Procyon lotor*
	Red fox	*Vulpes vulpes*
	Striped skunk	*Mephitus mephitus*
	Thirteen-lined ground squirrel	*Spermophillus tridecelineatus*
	White-tailed deer	*Odocoileus virginianus*
	White-tailed jackrabbit	*Lepus townsendii*
	Yellowbelly marmot	*Marmota flaviventris*
BIRDS:	American coot	*Fulica americana*
	American goldfinch	*Spinus tristis*
	American widgeon	*Mareca americana*
	Barn swallow	*Hirundo rustica*
	Black-capped chickadee	*Parus atricapillus*
	Blue-winged teal	*Anas discors*
	Brewer's blackbird	*Euphagus cyanocephalus*
	Brewer's sparrow	*Spizella breweri*
	Brown-headed cowbird	*Molothrus ater*
	Cinnamon teal	*Anas cyanoptera*

Table 8 (Continued)

	Common Name	Scientific Name
RDS: ontinued):	Common crow	*Corvus brachyrhynchos*
	Common night hawk	*Chordeiles minor*
	Eastern kingbird	*Tyrannus tyrannus*
	Gadwall	*Anas strepera*
	Golden eagle	*Aquila chrysaetos*
	Great horned owl	*Bubo virginianus*
	Horned lark	*Eremophila alpestris*
	House sparrow	*Passer domesticus*
	Hungarian partridge	*Perdix perdix*
	Killdeer	*Charadrius vociferus*
	Lark bunting	*Calamospiza melanocorys*
	Lark sparrow	*Chondestes grammacus*
	Loggerhead shrike	*Lanius ludovicianus*
	Magpie	*Pica pica*
	Mallard	*Anas platyrhynchos*
	Marsh hawk	*Circus cyaneus*
	Mountain bluebird	*Sialia currucoides*
	Mourning dove	*Zenaidura macroura*
	Pintail	*Anas acuta*
	Pinyon jay	*Gymnorhinus cyanocephala*
	Red-headed woodpecker	*Melanerpes erythrocephalus*
	Red-shafted flicker	*Colaptes cafer*
	Red-tailed hawk	*Buteo jamaicensis*
	Red-winged blackbird	*Agelaius phoeniceus*
	Ring-necked pheasant	*Phasianus colchicus*
	Robin	*Turdus migratorius*
	Rusty blackbird	*Euphagus carolinus*
	Sage grouse	*Centrocercus urophasianus*
	Sharp-tailed grouse	*Pediocetes phasianellus*
	Shoveller	*Spatula clypeata*
	Sparrow hawk	*Falco sparverius*
	Upland plover	*Bartramia longicauda*

Table 8 (Continued)

	Common Name	Scientific Name
BIRDS (continued):	Vesper sparrow	*Pooecetes gramineus*
	Violet-green swallow	*Tachycineta thalassina*
	Western kingbird	*Tyrannus verticalis*
	Western meadowlark	*Sturnella neglecta*
	White-breasted nuthatch	*Sitta carolinensis*
	White-crowned sparrow	*Zonotrichia leucophrys*
	Wilson's phalarope	*Steganopus tricolor*
	Yellow warbler	*Dendroica petechia*
REPTILES:	Racer	*Coluber constrictor*
	Hog-nosed snake	*Heterodon nasicus*
	Bull snake	*Pituophis catenifer*
	Western garter snake	*Thamnophis elegans*
	Plains garter snake	*Thamnophis radix*
	Common garter snake	*Thamnophis sirtalis*
	Prairie rattlesnake	*Crotalus viridis*
	Common snapping turtle	*Chelydra serpentina*
	Painted turtle	*Chrysemys picta*
	Western spiny softshell	*Trionyx spiniferus*
AMPHIBIANS:	Plains spadefoot	*Scaphiopus bombifrons*
	Great plains toad	*Bufo cognatus*
	Rocky mountain toad	*Bufo woodhousei*
	Boreal chorus frog	*Psendacris triseriata*
	Leopard frog	*Rana pipiens*
	Tiger salamander	*Ambystoma tigrinum*

2.(c)(1) Game Species

a. Big Game

Mule Deer (Odocoileus hemionus) - Mule deer utilize all vegetation types in the three sites, however, the ponderosa pine woodland is most often used. A mixture of open areas and cover for escape is the preferred habitat of the mule deer.(3) Important browse species include: ponderosa pine, creeping juniper, Rocky Mountain juniper, silver sagebrush, fringed sagebrush, big sagebrush, rubber rabbitbush, skunkbush, sumac and snowberry. The home range of the mule deer is 90-600 acres or more.(4)

Winter range is critical for most big game animals, and the mule deer is no exception. Winter range around Colstrip is close to summer range, usually being found on south and east facing slopes. The foods which are accessible above the snow are the most important, among which are big sage, fringed sage and silver sage. No areas of high winter concentration of mule deer have been observed in the three study areas (Figure 2).

The proposed mining sites are located in Hunting District 722 which is a two deer area, with the A tag usable on either white-tailed deer or mule deer.

Pronghorn Antelope (Antilocapra americana) - This is the only species of the family Antilocapridae. Optimum antelope habitat consists of open rolling sagebrush-grasslands relatively free of human disturbance.(3) Portions of the three areas may fit into this category, and it is in these areas that most observations of antelope are made. Sagebrush, big sage, fringed sage and silver sate, as well as weeds, are important food items throughout the year. The critical winter foods are the sagebrush species. The antelope is diurnal, and a band has a home range 2-4 miles in diameter.(4) No high winter concentration areas of pronghorn have been located on any of the three proposed mining sites (Figure 3).

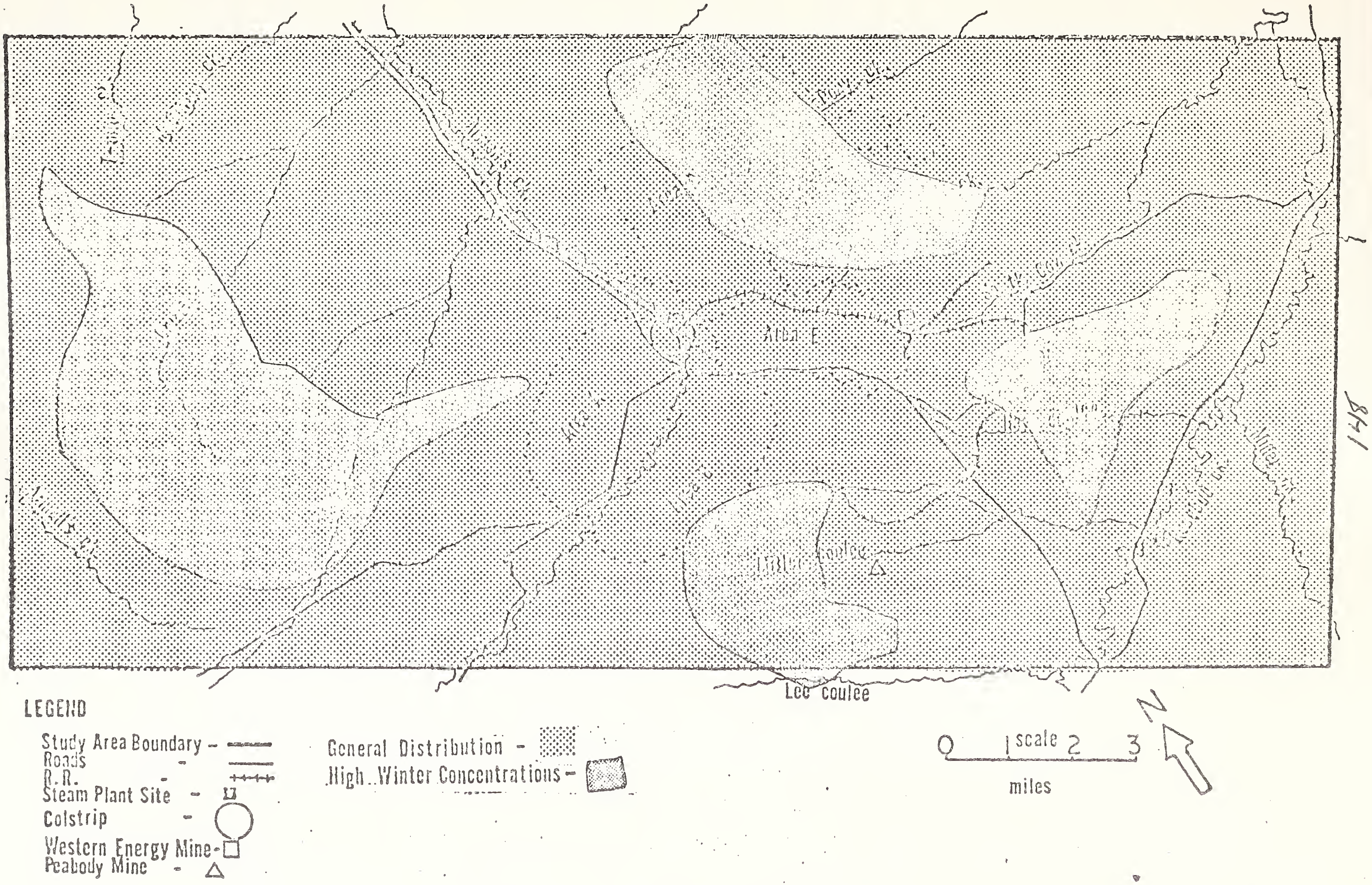
Lee coulee
Area F
LEGEND
Study Area Boundary -
Roads -
R.R. -
Steam Plant Site -
Colstrip -
Western Energy Mine -
Peabody Mine -
General Distribution -
High Winter Concentrations -
0 1 scale 2 3
miles
N

Figure 2 MULE [illegible]R DISTRIBUTION

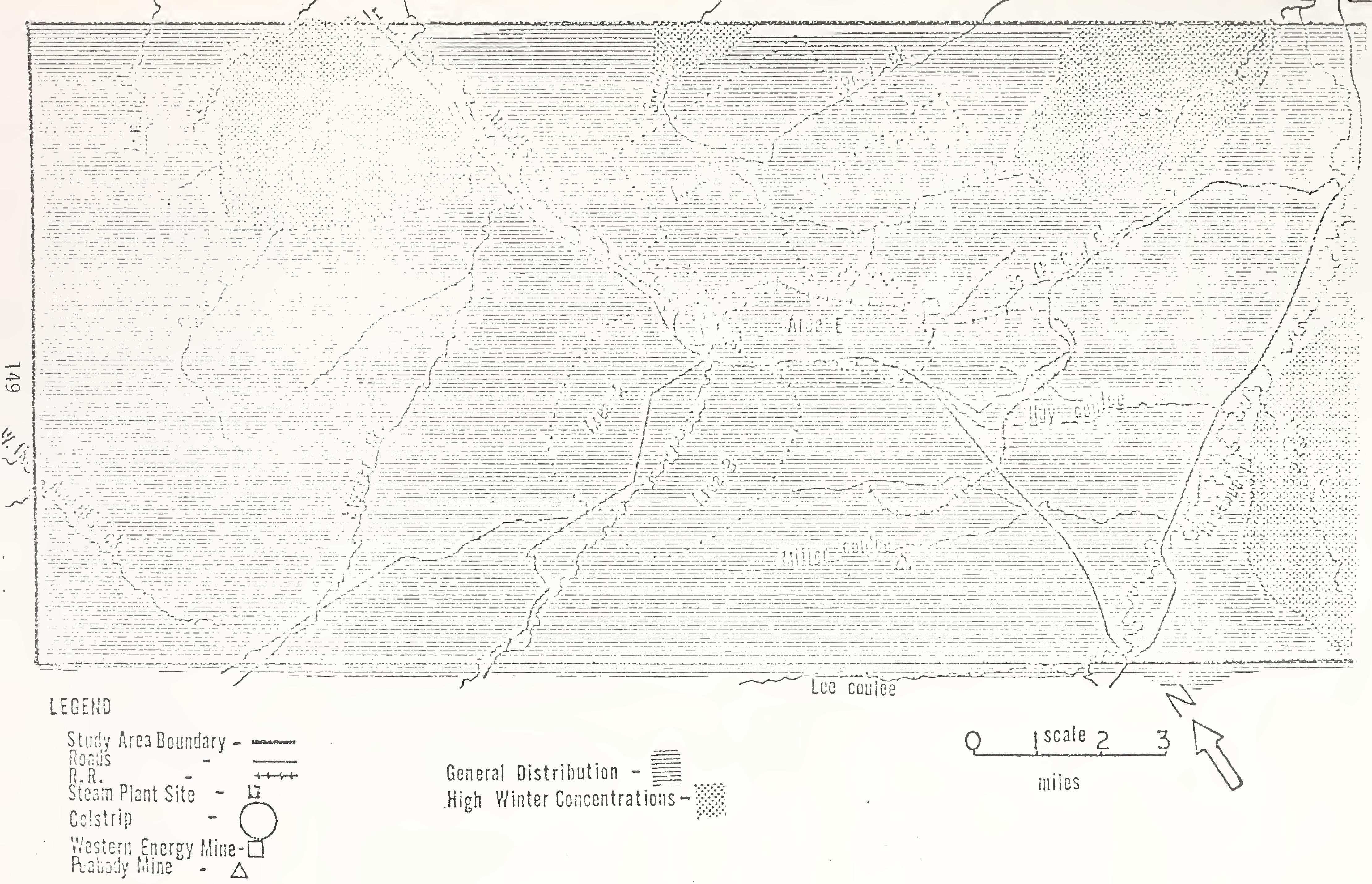
Area E
Hay coulee
Miller coulee
Lee coulee
LEGEND
Study Area Boundary -
Roads -
R.R. -
Steam Plant Site -
Colstrip -
Western Energy Mine -
Peabody Mine -
General Distribution -
High Winter Concentrations -
0 1 scale 2 3
miles
N

Figure 3 PRONGHORN ANTELOPE DISTRIBUTION

Hunting District No. 722 was assigned 200 permits for the 1972 hunting season. This area is considered to be less productive than some adjacent hunting areas.

White-tailed Deer (Odocoileus virginianus) - Deer of this species, being more forest mammals than the mule deer, are located along creek bottoms and particularly in the Rosebud Creek bottom within a 10-mile radius area of Colstrip. White-tailed deer are few in number in this locale and are not usually observed in Area E, Pit 6 or Area A-1. Browse and forbs are important foods found in the riparian habitat of the creek bottom zone. Preferred browse plants include chokecherry, serviceberry, skunkbush, snowberry and dogwood.(3)

White-tailed deer harvest results are combined with mule deer in Montana. The discussion of hunting in the above section on mule deer applies also to the White-tailed deer.

b. Game Birds

Sharptailed Grouse - A large part of this area is good sharptail habitat, and they are frequently observed. The best habitat for the sharptailed grouse is the upland prairie where heavy grazing or cultivation has not changed the naturally occurring vegetation.(3) Dense trees and shrubs plus standing grass are necessary parts of good sharptail habitat. Five sharptail dancing grounds were reported in the Colstrip area in 1969 and 1970. In addition, 103 females were sited on the observation route on April 25, 1970.(5) However, no sharptail dancing grounds were found on the three study areas (Figure 4).

Sage Grouse - The sage grouse can be found in the environs of Colstrip. Specific habitat requirements include big sage associations especially with herbaceous plants. Dandelion, goatsbeard and sagebrush make up three-fourths of the summer diet while big sage composed nearly 100

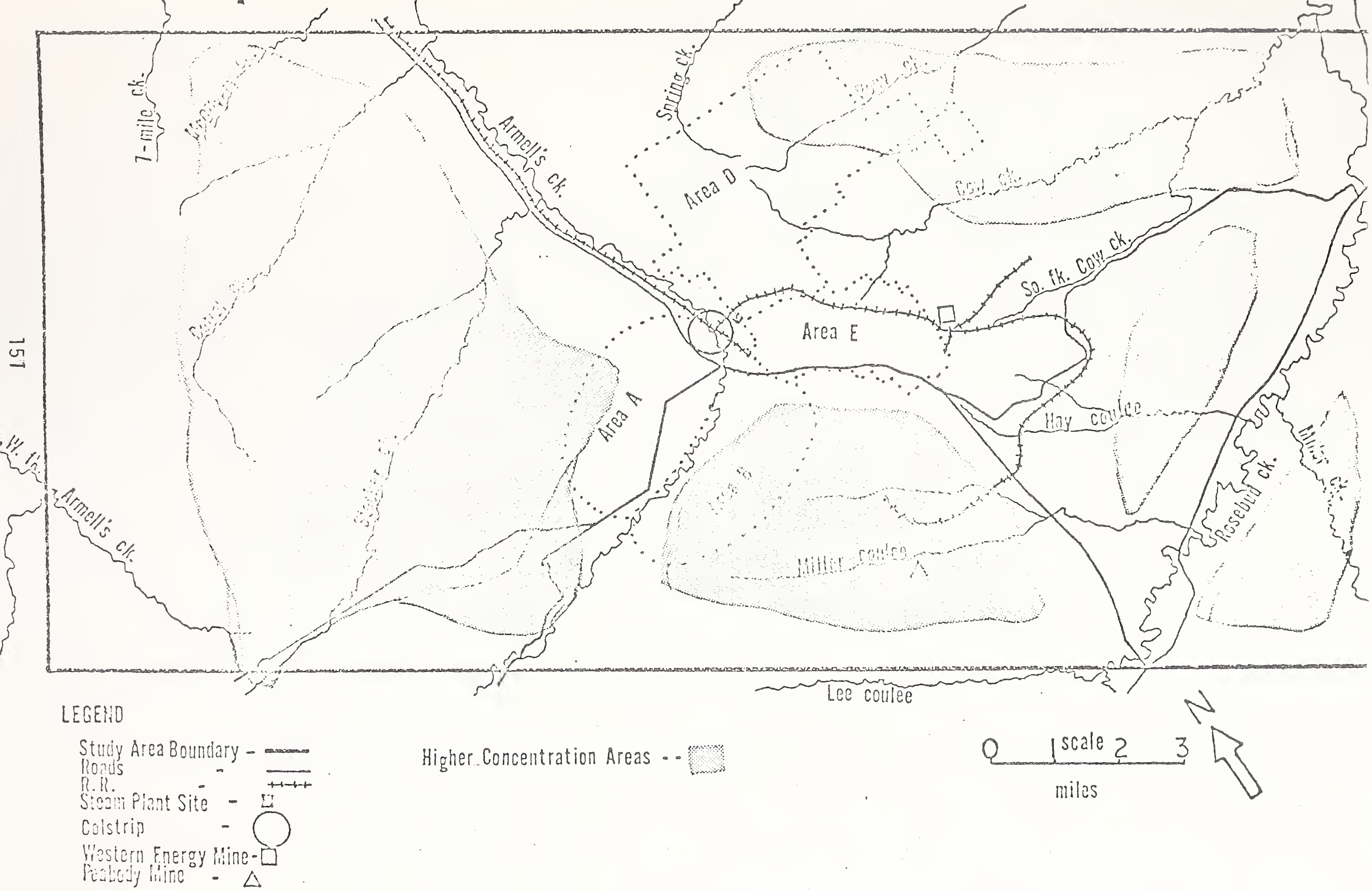
7-mile ck.
Armell's ck.
Spring ck.
Area D
Cow ck.
So. fk. Cow ck.
Area E
Area A
Area B
Hay coulee
Rosebud ck.
Miller ck.
Miller coulee
Lee coulee
W. fk.
Armell's ck.
LEGEND
Study Area Boundary
Roads
R.R.
Steam Plant Site
Colstrip
Western Energy Mine
Peabody Mine
Higher Concentration Areas
0
scale
2
3
miles
N

Figure 4 SHARP-TAILED GROUSE DISTRIBUTION

percent of the winter diet.(3) One strutting ground was observed in 1969-1970 near Colstrip but not on the study areas. The greatest number of females observed along a vehicle observation route was 22.(5) Sage grouse are occassionally observed in the study area (Figure 5).

Ringnecked Pheasant - The Armells Creek bottom and Rosebud Creek bottom are the nearest areas in which the pheasant is commonly found, however some have been observed in the study areas (Figure 5). Pheasnat habitat consists of grain fields weeds, brush and trees.(3) A call count survey along Armells Creek in 1973 reported a count of 2.5 per two minute period as compared to 13.3 along Rosebud Creek.

Hungarian Partridge - Huns are present but not usually observed in the study areas. Field edges are an important component of the Hungarian partridge habitat. The best habitat includes a combination of cultivated and non-cultivated land. An increase in grain growing has resulted in a favorable response in Hun numbers. Seven Hungarian partridge broods were observed in Hunting District 722 in 1968 and 1969 combined.(6) Hungarian partridges have been observed on area A-1 (Table 5).

c. Waterfowl

The study areas are located in the Central Flyway. The mallard, pintail and bluewinged teal are known to use the wet sites. The few small ponds in the area and around the spoils may provide water for waterfowl use; however, continued use of the area is dependent on food supplies and nesting habitat near the water source. The water habitat around Colstrip is presently used primarily as a migration resting area and is not very productive in terms of nesting or resident birds.

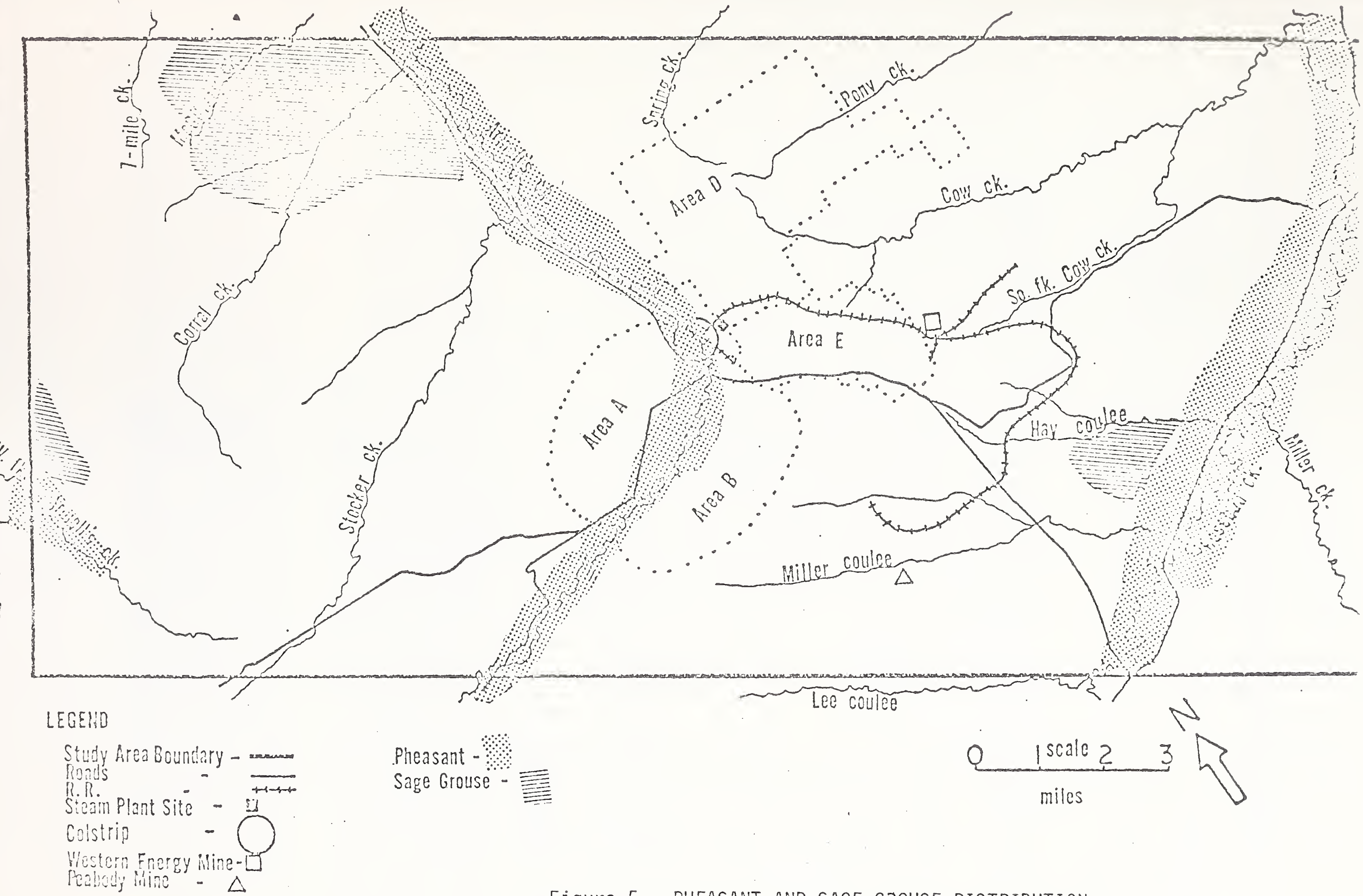
7-mile ck.
Corral ck.
Stocker ck.
Spring ck.
Pony ck.
Cow ck.
So. fk. Cow ck.
Area D
Area E
Area A
Area B
Hay coulee
Miller coulee
Miller ck.
Lee coulee
W. Fk.
N
0 1 scale 2 3
miles
LEGEND
Study Area Boundary -
Roads -
R.R. -
Steam Plant Site -
Colstrip -
Western Energy Mine-
Peabody Mine -
Pheasant -
Sage Grouse -

Figure 5 PHEASANT AND SAGE GROUSE DISTRIBUTION

2.(c)(2) Unique, Rare or Endangered Species

The golden eagle is known to be present in this part of the state but is infrequently observed. The golden eagle is not considered a rare or endangered species. Small mammals and rodents are the primary foods of this eagle.

Species which may be expected to be either in the general area of southeastern Montana or which may occur as migrants are:

Prairie falcon	(*Falco mexicanus*)
American peregrine falcon	(*Falco peregrinus anatum*)
Whooping crane	(*Grus americana*)
Eskimo curlew	(*Numenius borealis*)
Greater sandhill crane	(*Grus canadensis tabida*)

No endangered species, as defined by the Committee on Rare and Endangered Wildlife Species of the Bureau of Sports Fisheries and Wildlife, were identified on any of the study areas.

2.(c)(3) Other Wildlife

Furbearers and Predators -- The only furbearers, as defined by Montana Law, which may be found in the area are mink and muskrat. These species would most likely be located near the sump ponds of the coal mine. The mink feeds on small mammals, birds, eggs, frogs, crayfish and fish.(4) The food of the muskrat is primarily aquatic vegetation.

Mammal predators present in the areas are badger, raccoon, red fox, coyote, bobcat, long-tailed weasel and striped skunk. All of these species are primarily nocturnal but may be abroad during the day. The predators are wide ranging and may inhabit forested or open areas. The home range varies from 30 to 40 acres for the long-tailed weasel to the coyote which often ranges over 10 miles on its hunting route.(4) Small mammals are the major food source for the predators, but some like the coyote will eat almost anything.

2.(c)(4) Non-Game Animals

a. Mammals

Small mammals observed on the three study areas are listed in Tables 1, 2, and 3. The western deer mouse is the most widespread of the small mammals in the area, being found in all vegetative types. The deer mouse lives in burrows in the ground, in trees and stumps and feeds on seeds, nuts and insects.(4) This species rapidly reinvades disturbed areas and is important in the succession of biotic components to reclaim a disturbed site.

Another important small mammal species is the white-footed mouse which is present in many of the vegetative types. Preferred habitat is woody or brushy areas but is often found in open areas.(4)

The other small mammals are important in various vegetative types depending on their specific habitat requirements. The small mammal group as a whole is an important index of the success of reclamation procedures and although detailed census observations have not been made in Pit 6 areas already mined, there is an extensive population associated with reclaimed areas. This group of herbivores and insectivores is a vital link in the food chain of the ponderosa pine-sagebrush-grassland ecosystem. The establishment of small mammal populations is followed by the larger predators, both mammal and bird.

b. Birds

At least fifty species of birds (Table 8) are known to inhabit or have been observed in the mine study areas. This number includes bird predators and raptors. The only species using the old spoils esclusively were the redwinged blackbird and the Brewer's blackbird. Several species of Buteo hawks and falcons are known to use the area but none were observed in field studies on the site.(2) The number of birds fluctuates as their preferred habitat changes or is altered either naturally or by man.

c. Reptiles and Amphibians

The reptiles and amphibians known to occur within the study area are listed in Table 8.(2) The prairie rattlesnake is the only known poisonous snake known to be found in this region. The habitat requirements of the various snakes differs, however, the turtles and most amphibians require moist or wet environments. The toads are more adaptable to a variety of habitats. The herptofauna are of importance as members of the food chain as a food supply for larger predators.

d. Insects

The insect population is typical of the region. The most important disease related species present are the Rocky Mountain wood tick, vector of tularemia and Rocky Mountain spotted fever and the Anapheles mosquito, vector of malaria and encephalitis.

e. Fish

The two major streams, Armells and Rosebud, in the region do not support a large number of fish. Armells Creek is intermittent and thus only several small cyprinids and suckers may be found in residual pools. Rosebud Creek, although larger than Armells, supports very few sport fish. A number of stocked warm water fish and rainbow trout are found in the box-cut sump of the coal mine. The local residents use this small pond for fishing as well as swimming.

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2.(d) AERIAL PHOTOGRAPH

Aerial photographs of the Colstrip area have been submitted to the Department prior to this application.

2.(c) GROUNDWATER HYDROLOGY

The groundwater hydrologic conditions at Colstrip, especially groundwater quality and flow patterns in aquifers and spoil banks, were determined to help evaluate the environmental impact of strip mining in the area.

The most accessible and widely used aquifers (groundwater sources) in the Colstrip area, the sandstone and the coal beds, are integral parts of the total hydrologic system. They represent a dynamic and perpetual system -- as aquifers are recharged in some places, they are discharged in others, always maintaining a balance and adjusting to changes in climate and the demands of industry, agriculture and the town of Colstrip. The four wells which historically have supplied Colstrip's water needs each provide up to about 40 gallons per minute and are between 350 and 1600 feet deep. In addition, a 9000 foot well supplies 100 gallons per minute and two recently completed 650 foot wells each supply approximately 40 gallons per minute. Most wells in the study area produce less than 20 gallons of water per minute and range from about 20 to 350 feet deep, depending on the depts of the aquifers.(1)

Data for these studies were drawn from hydrologic studies of the area near Colstrip conducted by Renick,(2) by Hodder (3,4) and by the U. S. Geological Survey and the Montana Bureau of Mines and Geology, Hydrology Division.(5) In addition, field research, designed to collect data applicable to strip mining in the Colstrip area was conducted during March 1973.(6) Selected water wells were sampled to determine current groundwater chemistry. Spoil banks were sampled for permeability analysis, and a field value for permeability conducted on a selected test hole Pit 1, not on the 1974 mining area, was obtained via a field injection test. Aquifer and mine spoil waters were analyzed in the fields for calcium, magnesium, iron, manganese, bicarbonate, sulfate, chloride, fluride and nitrate. Specific conductance, temperature and pH were also determined.

Additional laboratory analyses for silica, total phosphate, boron, copper, chromium, lead, arsenic, mercury, cadmium, zinc, nickel, selenium, molybdenum and beryllium were conducted.

1. Hydrogeologic Units

The general geology of the Colstrip area is described in previous investigations.(7,8,9) Thickness and geologic units are generalized from these reports and from borehole logs provided by Western Energy Company. A stratigraphic column made for the Colstrip area is shown in Figure 6.

The youngest and uppermost unit in the area is the Tongue River member of the Fort Union Formation. This comprises interbedded sandstone, siltstone shale and clay. It has a maximum thickness of more than 700 feet southwest of Colstrip(7) and 445 feet at Colstrip. The thickness decreases northward and eastward; and in many parts, the member is absent because of erosion.

Of the many coal beds in the Tongue River member, (7,8,9) the Rosebud bed is particularly significant hydrologically because of its direct relation to mining. In the Colstrip area, the thickness of the Rosebud coal bed varies from about 20 to 29 feet. It is a major regional aquifer southwestward from Colstrip. Along most of the northern and northeastern outcrop of the Rosebud bed, the coal has burned and baked the overlying strata, leaving masses of varicolored -- but mostly red -- brittle, highly fractured rock commonly referred to as scoria or clinker. This clinker is highly permeable.

Over most of the area, a 6-inch to 20-foot thick bed of poorly permeable clay covers the Rosebud bed. Above this bed is a massive sandstone bed, commonly more than about 40 feet thick. Where this sandstone is below the water table, it forms a significant local aquifer.

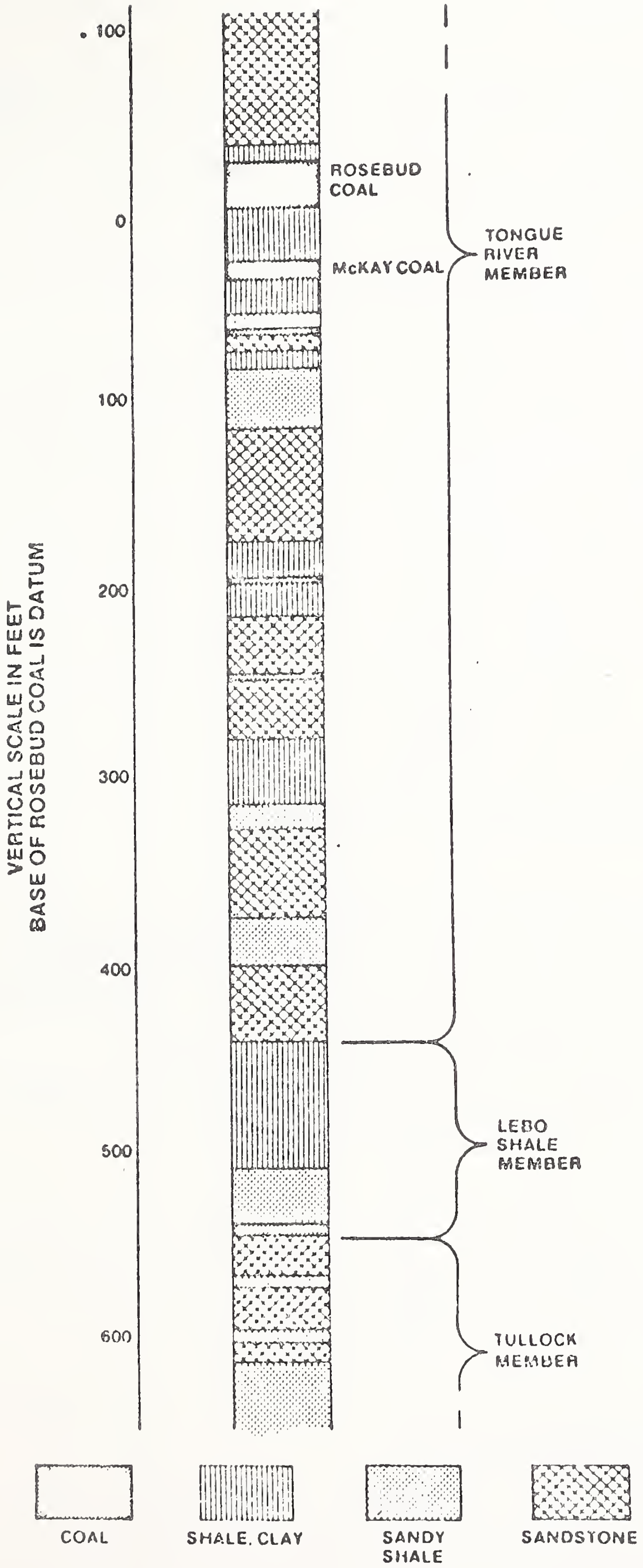
VERTICAL SCALE IN FEET
BASE OF ROSEBUD COAL IS DATUM
100
0
100
200
300
400
500
600
ROSEBUD COAL
McKAY COAL
TONGUE RIVER MEMBER
LEBO SHALE MEMBER
TULLOCK MEMBER
COAL
SHALE, CLAY
SANDY SHALE
SANDSTONE

Figure 6 STRATIGRAPHIC COLUMN OF THE FORT UNION FORMATION AT COLSTRIP, MONTANA

Directly underlying the Rosebud coal is a bed of poorly permeable clay (referred to as underclay) which varies in thickness from a few feet to almost 60 feet. Underlying this is a second coal bed, the McKay. The McKay coal bed is about 8 feet thick and has a slightly greater area extent than the Rosebud bed and, in the absence of the Rosebud or shallower aquifers, acts as the area aquifer.

Between 120 and 445 feet below the surface at Colstrip, within the Tongue River member and below the McKay Coal bed, are several sandstone aquifers interbedded with shale. The sandstone beds provide adequate water supplies for wells where shallower aquifers are absent. The town of Colstrip and many farmers draw their water supply from this aquifer. (1) Below the Tongue River member lie the Lebo shale and Tullock members of the Fort Union Formation.

2. Groundwater Quality

The chemical characteristics of groundwaters in the Colstrip area depend on source, time of the year and position in the flow system. Water quality in aquifers, ponds, spoil banks and Armells Creek near Colstrip (Figure 7) are given in Tables 9, 10, and 11. Current drinking water standards(10) and recommendations(11) and guidelines for livestock(12) are given in Tables 12, 13, and 14.

Waters for livestock consumption are classified for Montana(12): "salt concentrations up to 2500 mg/l are considered good; 2500-3500 mg/l, fair; 3500-4500 mg/l, poor; and above 4500 mg/l, unfit."

a. Major Constituents

Water samples from the Tongue River member sandstone beds located below the Rosebud coal (Samples 8, 9, 29, 30 and 36 on Table 9) have higher concentrations of sodium than calcium and higher concentrations of calcium than magnesium.

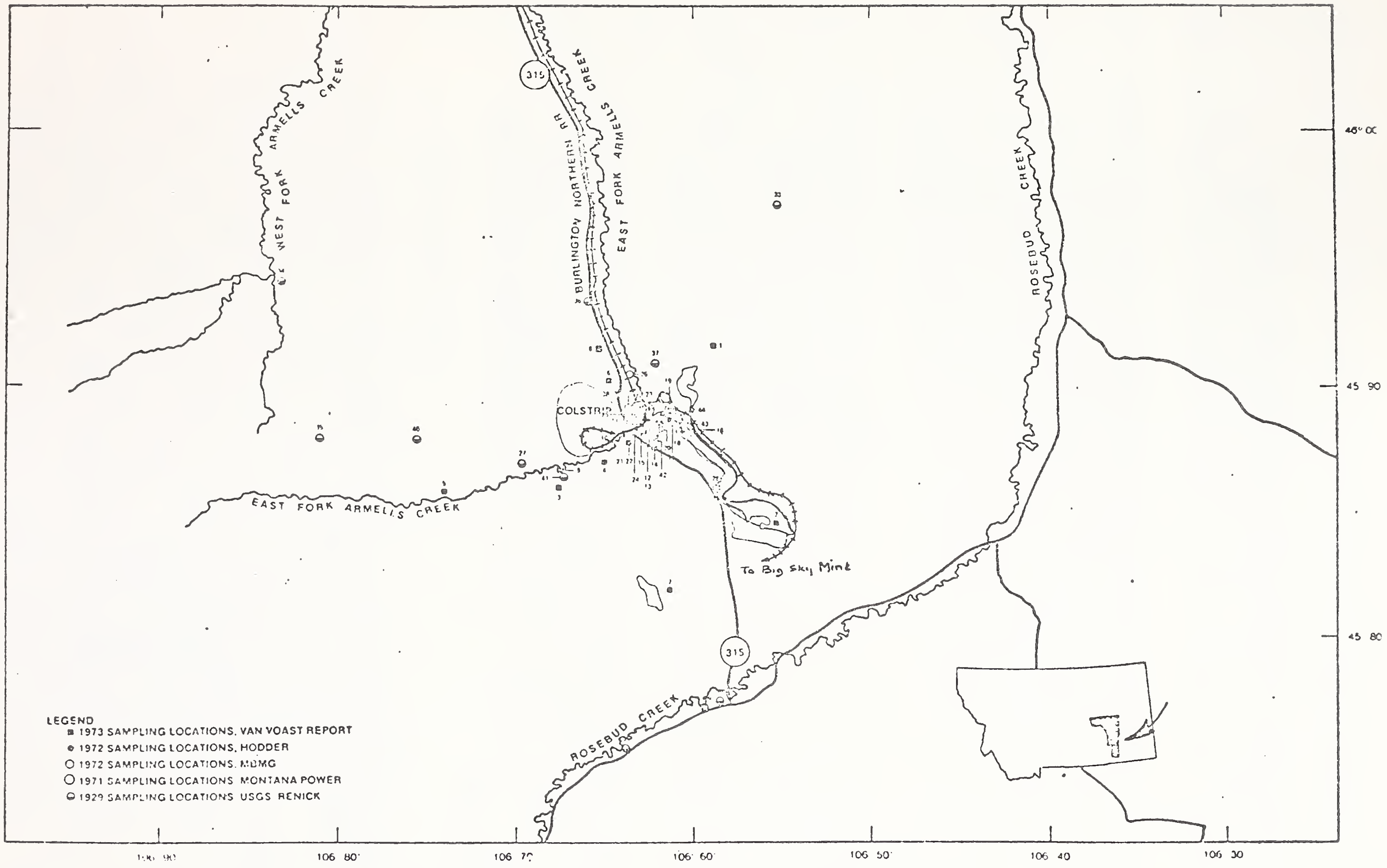
WEST FORK ARMELLS CREEK
EAST FORK ARMELLS CREEK
BURLINGTON NORTHERN RR
315
COLSTRIP
To Big Sky Mine
ROSEBUD CREEK
LEGEND
■ 1973 SAMPLING LOCATIONS, VAN VOAST REPORT
● 1972 SAMPLING LOCATIONS, HODDER
○ 1972 SAMPLING LOCATIONS, MBMG
○ 1971 SAMPLING LOCATIONS MONTANA POWER
○ 1929 SAMPLING LOCATIONS USGS RENICK
46° 00
45 90
45 80
106 80'
106 70
106 60'
106 50'
106 40
106 30
0 1 2 3 4 5 6
SCALE IN MILES

Figure 7 WATER QUALITY SAMPLING LOCATIONS

The major anion is sulfate rather than bicarbonate. The pH is slightly alkaline -- the values measured being 7.43 and 8.04. The Quality of these waters is below recommended drinking water standards.(10)

Waters from the McKay coal bed aquifer (Samples 5, 6 and 7 on Table 9 characteristically contain higher concentrations of magnesium than calcium. Again, sulfate is the major anion. These waters also are slightly alkaline; the pH averages 7.33 (range 6.85-7.65). The waters in this aquifer are more mineralized than in the Rosebud coal aquifer and usually do not meet the recommended drinking water standards.(1)

The least mineralized waters in the Colstrip area occur in the Rosebud coal bed (Samples 2, 3, 4, 27, 28, 35, 37 and 40 on Table 9 and 10). Calcium concentrations are higher than magnesium concentrations; sodium concentrations are relatively low. The major anion is bicarbonate rather than sulfate. As with the deep sandstone beds and the McKay aquifer, the pH is slightly alkaline, averaging 7.48 (range, 7.23-7.80).

A comparison of 1923 data for the Rosebud aquifer waters with 1973 data indicates that there are no major changes in the quality of these waters; that is, water quality was not affected significantly by commercial mining. The 1923 data predates any commercial mining activity near Colstrip.(2)

The most mineralized waters known in the area occur in the spoil banks and adjacent pond Water analyses from these spoils and ponds conducted in 1971(4) (Table 9) and 1973(6) (Samples 12 through 20 in Tables 9 and 10) show relatively high concentrations of calcium, magnesium and sulfate. Calcium concentrations range between 333 and 481 ppm, about ten times higher than in the Rosebud coal aquifer and about seven times higher than in the Tongue River member. Sulfate concentrations range between 1650 and 3640 ppm, about fifteen times higher than in the Rosebud aquifer and about twice as great as in the Tongue River member. Magnesium concentrations range between 317 to 848 ppm, about thirteen times higher than in the Rosebud aquifer and about seven times higher than in the

Tongue River member. Spoil waters are below drinking water standards and in some cases are not fit for livestock consumption.(12) None of the spoil water tested were acidic. The average pH being 8.39; the values range between 6.9 and 9.0.

A comparison of the March 1973 analyses of spoil water and pond samples with analyses made during the spring, summer and fall of 1971(4) shows that the concentrations of major elements is primarily a function of temperature and volume of water. Waters are more mineralized during warm and dry months and are more dilute during cold and wet months. The average pH values are slightly more alkaline in the summer (8.6) and fall (8.7) than spring (8.4).

Water quality in the East Fork of Armells Creek is the most varaible in the Colstrip area. A comparison of samples taken slightly upstream and downstream of Colstrip in March of 1973, with samples taken upstream and downstream from ponds in the stream channel during warm, dry periods of 1970 and 1971(5) show that, in both cases, water downstream from Colstrip is more mineralized and is richer in calcium, magnesium, sodium, bicarbonate and sulfate. Chemically, the downstream Armells Creek waters are similar to those of the spoil banks. These data, when coupled with spoils water flow data, strongly imply that seepage from the spoils escapes to the East Fork Armells Creek water course.

b. Minor Constituents

Previous water samplings of the Colstrip area were not analyzed for trace elements. In this study, selected water samples were analyzed for the trace elements known to be present in coal (Table 9). Of the trace elements found, fluorine, boron, copper, chromium, arsenic, cadmium, zinc and selenium levels are generally within the recommended federal standards for human consumption.(10,11) Manganese concentrations in the spoil bank waters, in one well (Sample 8 on Table 9) and in one sample upstream from the East Fork of Armells Creek, exceed the recommended federal standards for human consumption. Lead concentrations in the spoil bank waters and in the same well (Sample 8 on Table 9) also exceed recommended standards.

The concentrations of mercury and nickel in the waters of the Colstrip area are below drinking water standards adopted by some individual states.(10) Chloride concentrations were also below the drinking water standards for all water sources.

In previous as well as present analyses, iron concentrations were above the standards in some wells of the Tongue River member and below standards in the Rosebud coal bed and in some spoil bank waters. High iron concentrations could be attributed to the iron minerals (pyrite and marcasite) found in the coal.

c. Analytical Methods

General water quality data were obtained in the field, using a Hack (trade name) Chemical Kit.

The laboratory analysis was done by the analytical chemists of the Montana Bureau of Mines and Geology. They applied in most cases the U.S. Geological Survey recommended methods of analyzing(13) or "Standard Methods."(14) For most trace elements these methods coincide with the EPA recommendations. Mercury was analyzed by the EPA suggested method, flameless atomic absorption spectroscopy; and selenium was analyzed using the Perkin-Elmer high sensitivity As-Se apparatus.

3. Groundwater Flow

Groundwater flow in the shallow aquifers is controlled by surface drainage (topography), by geologic structure and areal extent and by the permeability of each hydrogeologic unit.

The Rosebud Mine crosses a major drainage divide between the East Fork Armells Creek and Rosebud Creek drainages. In the Rosebud Creek drainage, the mine area intercepts headwaters of the Cow Creek and South Fork Cow Creek sub-drainage as well as a very small part of the Hay Coulee sub-drainage (Figure 8).

Geologic structure strongly controls lateral groundwater flow patterns in the Rosebud coal bed. The almost impermeable underclay partially restricts vertical flow between aquifers and promotes a lateral flow within the more permeable coal. Rosebud bed structural contours show that the town of Colstrip and the Rosebud Mine are in a gentle southeastward trending syncline: the Rosebud coal and its underclay dip toward Colstrip from the north and west at gradients up to about 80 feet per mile. At the south end of the mined area, structural gradients are about 20 feet per mile.

Ground water flow in the Rosebud coal bed follows the structural gradient of the underclay except where the groundwater is diverted toward watercourses and mined areas. The watercourse of East Fork Armells Creek, for example, intercepts groundwater flow, diverting it into the Armells Creek drainage. Other flow patterns are toward the Rosebud Creek drainage and toward the Rosebud Mine. The aquifer is recharged from its outcrop north of Colstrip (particularly where burned) and from uplands west of there.

Lateral flow patterns for the sandstone aquifer, located closely above the Rosebud coal, and for the McKay coal bed aquifer, within 50 feet below the Rosebud coal, are likely similar to those shown in Figure 9.

Vertical flow between aquifers is controlled by pressure differential between aquifers and by thickness and permeability of confining beds. Since the aquifers in the Tongue River member of the Fort Union Formation are generally separated by poorly permeable strata (confining

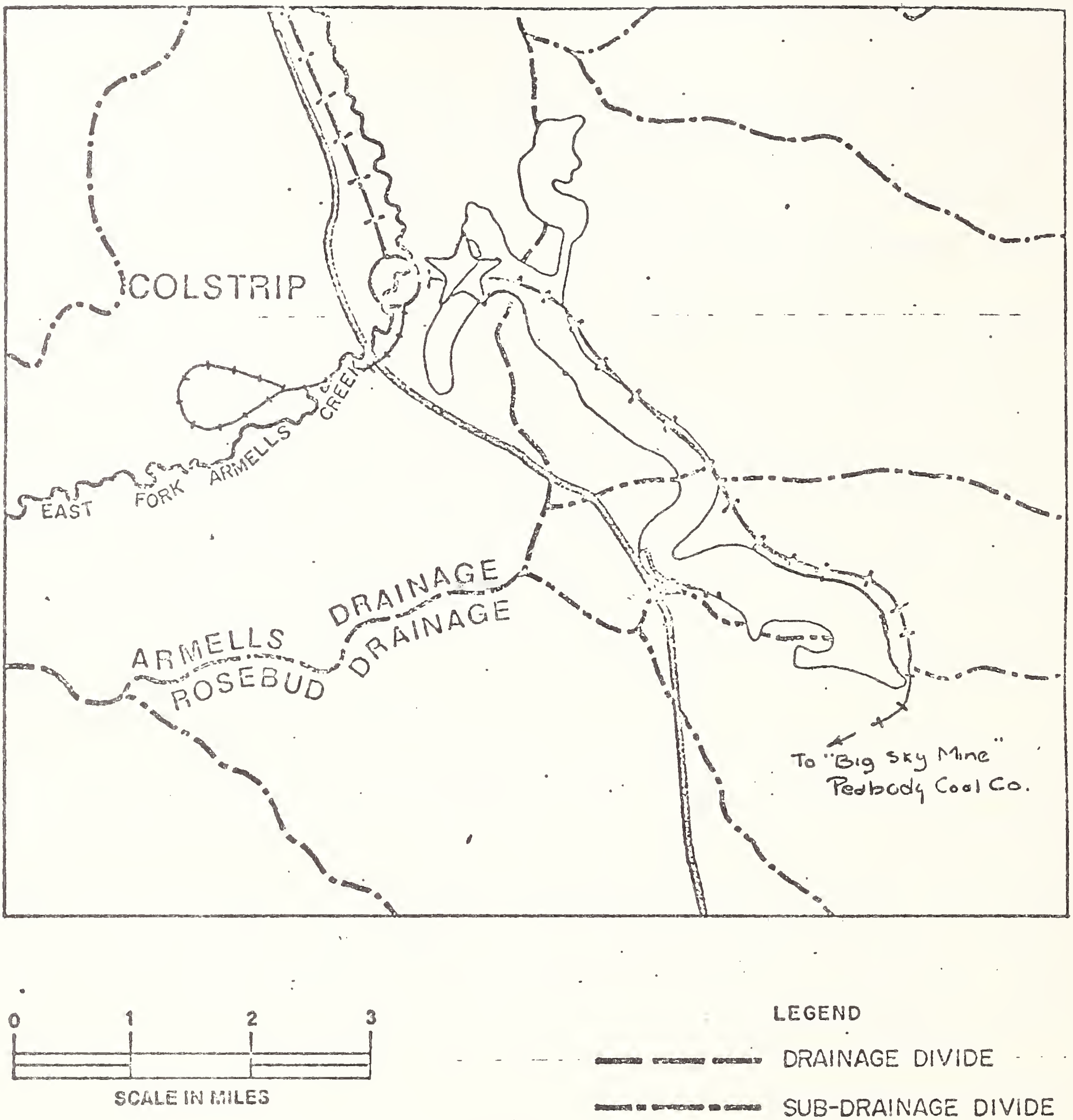
COLSTRIP
EAST FORK ARMELLS CREEK
ARMELLS DRAINAGE
ROSEBUD DRAINAGE
To "Big Sky Mine"
Peabody Coal Co.
0 1 2 3
SCALE IN MILES
LEGEND
DRAINAGE DIVIDE
SUB-DRAINAGE DIVIDE

Figure 8 DRAINAGE DIVIDES NEAR COLSTRIP

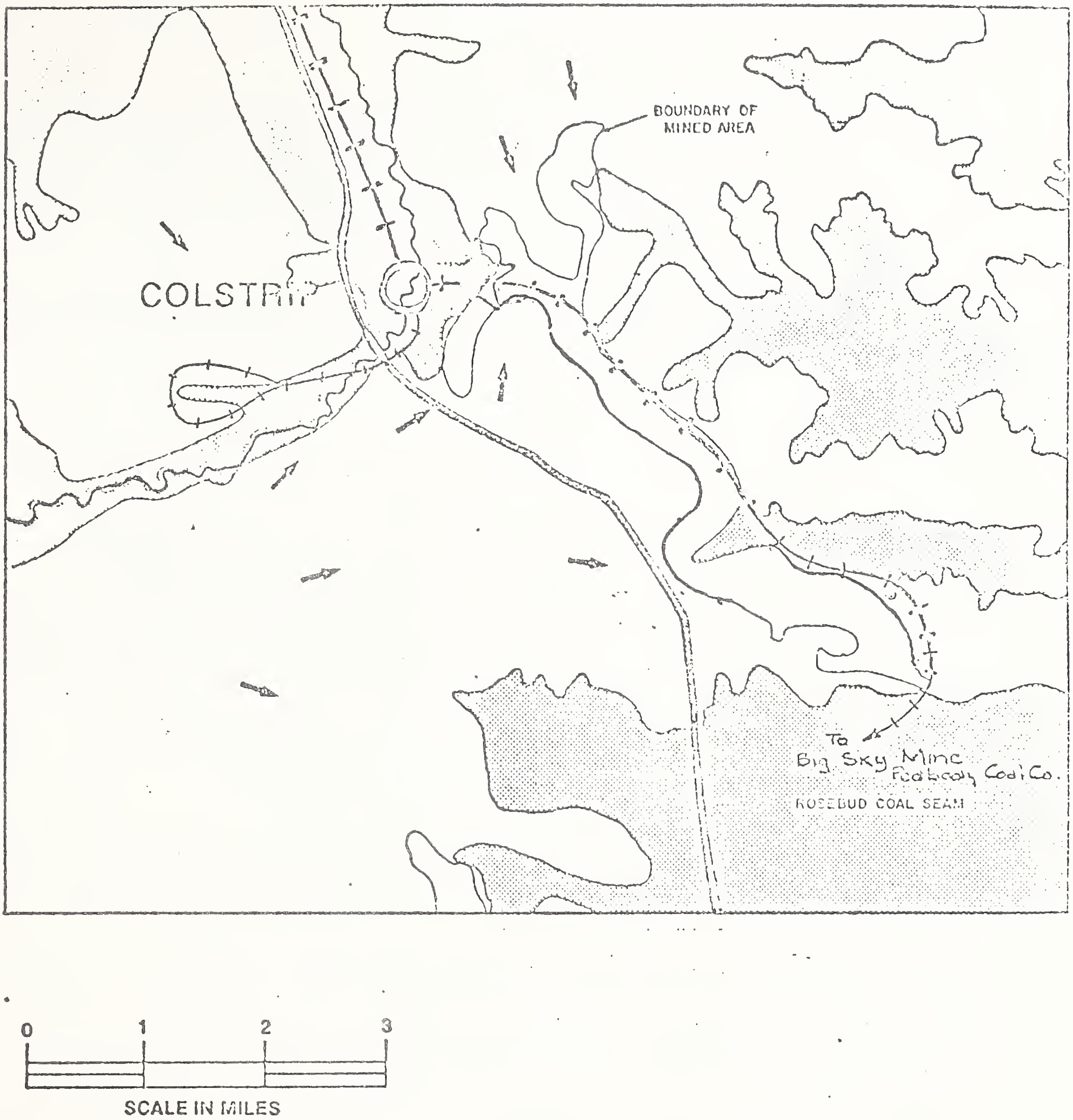
BOUNDARY OF MINED AREA
COLSTRIP
To
Big Sky Mine
Peabody Coal Co.
ROSEBUD COAL SEAM
0
1
2
3
SCALE IN MILES

Figure 9 GROUNDWATER FLOW PATTERNS IN SHALLOW AQUIFIERS NEAR COLSTRIP

beds), vertical flow is extremely slow. In the vicinity of the Rosebud Mine at Colstrip, hydrostatic pressures in the Tongue River member decrease with depth, indicating that flow is downward. Based on the separation of the two coal beds, the pressure differential between the Rosebud and the McKay aquifers ranges from about 50 feet to only a few feet of head. All well water levels in the McKay coal bed and examined in this study are lower than the base of the Rosebud coal bed.

4. Permeability

Permeability of a rock or soil is defined(15) as a measure of its ability to transmit fluid, such as water under a hydropotential gradient. Permeability values for the rocks and soils in the areas the 1974 mining application applies for are not available. The hydrological study presently being conducted (begun July, 1973) as a cooperative effort between the Montana Bureau of Mines and Geology and Western Energy Company in the Colstrip area will determine these permeabilities.

The hydrological study conducted in March 1973(6) in the Colstrip area determined the permeabilities at Pit 1 in the laboratory and in the field. Laboratory determinations ranged from 2.1 x 10-3 to 1.0 gal/day/ft.^{2}. These values were from undisturbed drive sample and illustrate vertical permeability. An injection test gave a horizontal permeability value of 95 ± 25 gal/day/ft.^{2} for the spoils below the water table at that location. In most stratified materials, the horizontal permeability is greater than the vertical permeability.

Neither the laboratory nor field permeability values are considered truly representative.(6) The laboratory values represent specific points, mostly clay, sand and silt, that do not posses any fissures or fractures and therefore do not reflect the overall spoil texture or structure. As such, they probably tend to be lower than the average actual spoil permeability. The field permeability values represent a greater volume of spoil, including local texture and structure. However, since much of the injected water was used to saturate the cone created by the injection, this permeability value is higher than the actual permeability field value. A comparison of test methods and permeability values suggests that the average vertical permeability for Pit 1 spoils is between about 0.5 and 50 gal/day/ft^2.(6)

The permeability of the underclay was too low to determine by the laboratory or field methods used in this study. Permeability values for similar underclay, 10 miles west of Decker, Montana, were reported to be below 0.004 gal/day/ft^2.(16): other permeability values for similar clays range from 0.001 to 1.0 gal/day/ft^2.(17)

5. Transmissivity

Transmissivity is determined(15) as the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient.

Transmissivity values for the areas this permit application refers to are not available. An approximate maximum transmissivity value can be estimated from well data. Several wells in the area can provide more than 20 gpm of water without drawdowns of more than 100 feet. The specific capacity of such wells would then be:

$$\text{Specific Capacity} = \frac{20 \text{ gpm}}{100 \text{ ft.}} = 0.2 \text{ gpm/ft.}$$

From theoretical flow equations(18) an approximate maximum transmissivity of 1,000 gpd/ft. can be calculated.

Test hole injections in Pit 1 spoils showed a maximum transmissivity of 330 and a minimum of 188 gal/day/ft.

6. Production Date

The availability of groundwater from wells relies upon the hydraulic conductivity of an aquifer. Hydraulic conductivity is the coefficient relating groundwater flow (gal/min) to cross section area (ft^2) and hydraulic gradient (ft/ft).(15) Hydraulic conductivity is sometimes called "permeability" or "coefficient of permeability".

A tight aquifer structure may not release groundwater easily to a well. Wells in the Colstrip area are typically of 20 gpm per 100 feet of drawdown (static water level less pumped water level). Specific capacity of such wells (water flow rate per foot of drawdown) is accordingly 0.04 to 0.2 gpm/foot.

Deep wells penetrating far into the sand/sandstone strata are capable of greater production. In the town of Colstrip, Western Energy Company directs up to 35 gpm of groundwater 24 hours per day from aquifers well below the Rosebud and McKay seams. Water tables vary, well logs indicate well penetration through successor aquicludes and aquifers. Net productive sandthicknesses rangebetween 27 feet and 116.

A list of all wells within the close vicinity of the 1974 mining area and their production is provided in Table 15.

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WATER SAMPLES NEAR COLSTRIP

	Arsenic (As)	Mercury (Hg)	Cadmium (Cd)	Zinc (Zn)	Nickel (Ni)	Selenium (Se)	Beryllium (Be)	Date Sampled	Type of Sample	Remarks, Credits, Water Source
05	<0.002	<0.0002	<0.01	<0.01	<0.04	<0.005	<0.02	3-24-73	mine pit	Pit number 6; drainage from Rosebud coal bed
05	<0.002	<0.0002	<0.01	0.10	<0.04	<0.005	<0.02	3-18-73	well	Leo Farley owner; Rosebud coal aquifer
05	<0.002	0.0003	<0.01	0.05	<0.04	<0.005	<0.02	3-19-73	well	Leo Farley owner; sandstone aquifer 350 feet below Rosebud coal
10	<0.002	<0.0002	<0.01	0.02	0.04	<0.005	<0.02	3-20-73	well	B & R Food Town (store, bar, restaurant); sandstone aquifer 200 ft below Rosebud coal gas station
6	<0.002	<0.0002	<0.01	0.01	0.05	<0.005	<0.02	3-20-73	Pit 1 pond	"Swimming hole" in Pit 1 spoils; slight ice cover
9	<0.002	<0.0002	<0.01	0.19	0.14	<0.005	<0.02	3-23-73	Pit 1 spoils	Spoils water from spoils test-hole number 2
3	<0.002	<0.0002	<0.01	0.34	0.06	<0.005	<0.02	3-23-73	Pit 1 spoils	Spoils water from spoils test-hole number 3
3	<0.002	<0.0002	<0.01	0.45	0.10	<0.005	<0.02	3-23-73	Pit 1 spoils	Spoils water from spoils test-hole number 4
6	<0.002	<0.0002	<0.01	0.27	0.03	<0.005	<0.02	3-23-73	Pit 1 spoils	Spoils water from spoils test-hole number 5
5	<0.002	<0.0002	<0.01	0.01	<0.04	<0.005	<0.02	3-20-73	ditch	Ditch providing local drainage to E. Fork Armells Creek
5	<0.002	<0.0002	<0.01	0.01	<0.04	<0.005	<0.002	3-20-73	stream	E. Fork Armells Creek upstream from Colstrip; estimated discharge 0.2 cfs
	-	--	-	-	-	-	-	8-12-72	stream	E.Fork Armells Crk. upstream from Colstrip, stream ponded, no flow; MBMG analysis
	-	--	-	-	-	-	-	8-12-72	stream	E.Fork Armells Crk. downstream from Colstrip, stream ponded, no flow; MBMG analysis
	-	--	-	-	-	-	-	8-26-71	stream	E.Fork Armells Crk. 1500 yds. downstream from Colstrip; Yapuncich, Sanderson, & Brown, analysis, Billings
	-	--	-	-	-	-	-	7-31-23	well	Water from Rosebud coal, USGS analysis(30)
	-	--	-	-	-	-	-	7-22-23	well	Water from Rosebud coal, USGS analysis(30)
	-	--	-	-	-	-	-	7-15-23	well	Aquifer probably sandstone 250 ft below Rosebud coal, USGS analysis(30)
	-	--	-	-	-	-	-	7-15-23	well	Aquifer probably sandstone 300 ft below Rosebud coal, USGS analysis(30)
	-	--	-	-	-	-	-	7-15-23	well	Alluvium aquifer along Rosebud Creek, USGS analysis(30)
	-	--	-	-	-	-	-	7-20-23	well	Alluvium aquifer, USGS analysis(30)
	-	--	-	-	-	-	-	9-14-23	well	Water from sandstone in lower Tongue River member, USGS analysis(30)
	-	--	-	-	-	-	-	7-30-23	well	Water from Tullock member, USGS analysis(30)
	-	--	-	-	-	-	-	7-30-23	well	Water from Rosebud coal bed, USGS analysis(30)
	-	--	-	-	-	-	-	1923	well	Sandstone aquifer about 250 feet below Rosebud coal, Northern Pacific Railway analysis(30)
	-	--	-	-	-	-	-	1923	spring	Water from Rosebud Coal, Northern Pacific Railway analysis(30)
	-	--	-	-	-	-	-	1923	test boring	Aquifer unknown, Northern Pacific Railway analysis(30)
	-	--	-	-	-	-	-	1923	test boring	Aquifer unknown, Northern Pacific Railway analysis(30)
	-	--	-	-	-	-	-	1923	coal shaft	Water from Rosebud coal, Northern Pacific Railway analysis(30)
	-	--	-	-	-	-	-	1923	stream	Water hole 6 ft deep in E.Fork Armells Crk., Northern Pacific Railway analysis(30)

Table 9

LABORATORY CHEMICAL ANALYSIS RESULTS OF WATER SAMPLES NEAR C

Sample Number (L=laboratory analysis)	Land Surface Altitude, ft	Water Temperature, °C	Laboratory specific conductance, micromhos per centimeter at 25°C	Laboratory pH	Dissolved Solids (calculated: Nos. 1-14 and 21-26, evap. at 180°C: Nos. 15-20)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Iron (Fe)	Silica (SiO_2)	Total Phosphate (PO_4)	Flouride (F)	Manganese (Mn)	Boron (B)	Copper (Cu)	Chromium (Cr)	Lead (Pb)	Arsenic (As)	Mercury (Hg)
2L	3155	12	624	8.19	535	45	47	20	2.8	244	0	104	3.3	47.4	0.1	21	0.13	0.2	0.05	0.21	<0.02	<0.02	<0.05	<0.002	<0.0002
3L	3357	9	869	7.51	802	72	74	26	3.0	451	0	147	5.9	4.1	0.1	19	0.08	0.2	0.02	<0.1	<0.02	<0.02	<0.05	<0.002	<0.0002
9L	3330	13	2610	8.04	2032	14	3.4	603	3.6	413	0	978	7.9	0.1	0.6	7.1	0.09	0.4	0.02	<0.1	<0.02	<0.02	<0.05	<0.002	0.0003
8L	--	10	3460	7.43	3155	163	153	550	10	547	0	1704	13	0.2	1.3	13	<0.05	0.5	0.09	0.45	<0.02	<0.02	0.10	<0.002	<0.0002
13L	3235	6	3390	7.97	3332	105	541	225	19	285	0	2630	23	0.4	0.1	2.9	0.07	0.1	0.22	0.26	<0.02	<0.02	0.15	<0.002	<0.0002
17L	3253	-	4950	7.32	5626	481	748	23	11	697	0	3640	3.2	0.3	0.3	17	0.13	0.2	4.7	0.17	0.02	0.02	0.19	<0.002	<0.0002
18L	3257	-	2313	7.19	2031	347	280	52	15	500	0	1650	11	0.5	0.4	24	0.10	0.1	0.32	0.96	0.03	<0.02	0.13	<0.002	<0.0002
19L	3252	-	3560	7.04	4174	330	477	81	13	973	0	2212	12	1.1	1.1	19	0.09	0.1	5.0	0.46	0.03	0.02	0.10	<0.002	<0.0002
20L	3264	-	2934	6.94	3058	333	317	58	12	629	0	1668	14	4.4	0.1	21	0.15	0.1	2.2	1.2	<0.02	<0.02	0.16	<0.002	<0.0002
11L	3222	9	1725	7.61	1545	138	132	106	9.3	346	0	795	10	0.5	0.1	7	0.12	0.2	0.29	0.29	<0.02	<0.02	<0.05	<0.002	<0.0002
22L	3243	9	2370	7.52	2316	195	219	127	12	593	0	1131	12	0.2	0.5	20	0.08	0.2	1.8	0.45	<0.02	<0.02	<0.05	<0.002	<0.0002
24L	3243	20	2220	8.09	2011	110	218	145	13	342	0	1150	12	1.2	<0.1	20	-	0.2	0.01	-	-	-	-	-	--
25L	3222	18	3560	7.38	3726	335	319	286	5.6	499	0	2203	29	19	<0.1	25	-	0.2	0.01	-	-	-	-	-	--
26L	--	-	3636	8.2	3339	216	423	255	-	770	0	2103	13	0	0.1	-	-	-	0	-	-	-	-	-	--
27L	--	-	--	--	334	13	17	20		63	0	56	6	24	6.9	38	-	-	-	-	-	-	-	-	--
28L	--	-	--	--	366	54	45	16		320	19	49	3	Tr.	Tr.	14	-	-	-	-	-	-	-	-	--
29L	--	-	--	--	1834	104	92	346		390	0	1003	9	2.2	1.2	13	-	-	-	-	-	-	-	-	--
30L	--	-	--	--	1160	14	9.1	330		371	0	531	8	1.9	Tr.	10	-	-	-	-	-	-	-	-	--
31L	--	-	--	--	2473	194	172	296		547	0	1300	20	1	8.	18	-	-	-	-	-	-	-	-	--
32L	--	-	--	--	1334	90	122	143		593	0	537	6	2	0.8	18	-	-	-	-	-	-	-	-	--
33L	--	-	--	--	1454	143	160	63		464	0	716	8	5	2.5	23	-	-	-	-	-	-	-	-	--
34L	--	-	--	--	732	4.4	2.4	305		732	36	2.8	18	Tr.	0.40	9.2	-	-	-	-	-	-	-	-	--
35L	--	-	--	--	1351	144	135	92		517	0	634	11	1.5	5.3	28	-	-	-	-	-	-	-	-	--
36L	--	-	--	--	2029	67	12	233		1210	-	1045	20	10	-	-	-	-	-	-	-	-	-	-	--
37L	--	-	--	--	718	114	51	33		357	-	268	5	-	-	-	-	-	-	-	-	-	-	-	--
38L	--	-	--	--	2446	114	238	253		426	-	1343	35	36	-	-	-	-	-	-	-	-	-	-	--
39L	--	-	--	--	1558	136	103	244		337	-	684	-	24	-	-	-	-	-	-	-	-	-	-	--
40L	--	-	--	--	1102	93	87	153		794	-	259	10	-	-	-	-	-	-	-	-	-	-	-	--
41L	--	-	--	--	962	128	106	146		497	-	295	7	-	-	-	-	-	-	-	-	-	-	-	--

Table 10

FIELD CHEMICAL ANALYSES RESULTS OF WATER NEAR COLSTRIP, MONTANA
(Data are in milligrams per liter [mg/l], except as indicated)

Sample Number (Field analysis)	Land surface Altitude, feet	Water Temperature, °C	Calcium (Ca)	Magnesium (Mg)	Bicarbonate (HCO_3)	Carbonate	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Iron (Fe)	Manganese (Mn)	Specific conductance (micromhos/cm at 25°C)	pH	Date Sampled	Sample Type	Remarks, water source
1F	3430	5	123	73	465	0	312	32	0.4	5.2	0	0.1	1010	7.10	3-16-73	Spring	Clair Streeter owner; sandstone aquifer 100 ft. above Rosebud coal
2F	3165	12	50	52	378	0	131	7.0	0.3	46	0	0	600	7.80	3-24-73	Mine pit	Pit 6; seepage from Rosebud coal bed.
3F	3357	9	93	62	453	0	212	7.5	0.3	0.9	0.1	-	875	7.42	3-18-7	Well	Leo Farley owner; Rosebud coal aquifer
4F	3294	-	120	153	525	0	783	10	0.4	0	-	0.2	1330	7.23	3-15-73	Well	Jim Snider owner; Rosebud coal aquifer
5F	--	-	140	153	366	0	837	13	0.5	6.0	1.0	-	1650	7.60	3-18-73	Well	Leo Farley owner; McKay coal aquifer
6F	3238	8	204	216	294	0	1625	13	0.7	0.3	0.2	0	2400	6.85	3-16-73	Pit	Bulldozer pit in McKay coal
7F	--	-	133	317	565	0	1625	14	0.5	0.5	1.8	-	2500	7.65	3-16-73	Well	Duke McRae owner; McKay coal aquifer
8F	--	10	162	154	564	0	1875	16	1.6	0	1.5	0.2	3400	7.35	3-20-73	Well	B and R Food Town; sandstone aquifer 200 ft below Rosebud coal
9F	3330	13	20	0	431	0	1440	12	0.8	0.3	1.0	-	2300	7.80	3-19-73	Well	Leo Farley owner; sandstone aquifer 350 ft below Rosebud coal
10F	3243	-	126	131	262	0	775	15	0.5	0.3	0.4	-	1500	7.42	3-23-73	Well	Jim Snider owner; alluvial aquifer along E. Fork Armells Creek
11F	3222	9	143	123	355	0	975	13	0.6	0.2	0.1	-	1630	7.80	3-19-73	Ditch	Ditch east of Armells Creek, collects seepage from water table
12F	3235	5	100	394	242	0	2052	20	0.8	0	0.1	0.2	2950	7.85	3-15-73	Pit 1 pond	"Swimming hole" in Pit 1 spoils; partial ice cover
13F	3235	6	110	439	292	0	2250	27	1.0	0.2	0.1	-	3750	7.75	3-20-73	Pit 1 pond	"Swimming hole" in Pit 1 spoils; slight ice cover
14F	3237	-	234	222	372	0	1510	12	0.9	0.4	0	-	2200	7.37	3-15-73	Spring	Spring supplying "swimming hole" at southwest end; sandstone aquif
15F	3229	-	293	377	373	0	2000	18	0.9	0.1	0	-	3300	7.22	3-15-73	Ditch	Ditch draining Pit 1 spoils; ponded, no flow
16F	3215	-	150	310	220	0	1740	13	0.6	0	0.5	0.2	2200	7.50	3-15-73	Pit 2 pond	Shallow pond in Pit 2 spoils
17F	3258	-	490	745	670	0	4000	7.5	1.4	0.1	0	-	5000	7.20	3-23-73	Pit 1 spoils	Spoils water from test-hole number 2.
18F	3257	-	393	264	550	0	2030	13	0.9	0.1	0	-	2800	7.10	3-23-73	Pit 1 spoils	Spoils water from test-hole number 3.
19F	3252	-	405	480	975	0	2620	15	1.0	0	0	-	3800	6.85	3-23-73	Pit 1 spoils	Spoils water from test-hole number 4
20F	3254	-	343	335	622	0	2100	13	0.9	0.7	0	-	2900	6.76	3-23-73	Pit 1 spoils	Spoils water from test-hole number 5
21F	3244	7	180	226	648	0	1312	15	0.6	0	0.6	1.7	2000	7.45	3-15-73	Armells Creek	Upstream from Colstrip at highway bridge, est. 0.2 cfs
22F	3244	9	206	208	634	0	1250	12	0.7	1.5	0.2	0.7	2200	7.41	3-20-73	Armells Creek	Upstream from Colstrip at highway bridge, est. 0.2 cfs
23F	3222	7	210	224	570	0	1125	16	0.9	0	0.6	-	2100	7.62	3-15-73	Armells Creek	Downstream from Colstrip at county road bridge, est 0.2 cfs

Table 11

WATER ANALYSIS DATA RECORDED AT THREE DEPTHS[32] (in ppm)

June 15, August 15, October 23, 1971

	Spring			Summer			Fall		
	Depth (feet)								
Mine Pit No. 1	Surface	5 - 9	9 - 15	Surface	5	9	Surface	5	9
Temperature, F°	76.5	72.0	65.8	82.0	74.5	70.5	46.5	47.0	46.5
pH	8.7	8.7	8.5	9.3	9.0	8.7	9.1	8.9	8.7
Sulfate	803.0	841.0	906.0	1033.0	912.0	978.0	1070.0	1048.0	1085.0
Conductivity*	4800.0	4850.0	5025.0	5225.0	5175.0	5150.0	4925.0	4825.0	4875.0
Calcium	124.0	131.0	151.0	124.0	110.0	128.0	130.0	128.0	137.0
Magnesium	633.0	640.0	670.0	780.0	789.0	788.0	716.0	728.0	740.0
Sodium	240.0	247.0	261.0	316.0	317.0	312.0	302.0	298.0	302.0
Mine Pit No. 2									
Temperature, F°	75.3	70.3	58.0	77.7	72.3	67.0	46.3	44.3	46.3
pH	8.4	8.3	8.3	8.8	8.4	8.1	8.7	8.8	8.5
Sulfate	413.0	713.0	1051.0	663.0	697.0	1014.0	857.0	919.0	930.0
Conductivity*	2967.0	4133.0	5200.0	4067.0	4000.0	5333.0	4000.0	4050.0	4300.0
Calcium	190.0	294.0	365.0	288.0	284.0	372.0	320.0	311.0	342.0
Magnesium	347.0	519.0	742.0	560.0	561.0	809.0	581.0	596.0	627.0
Sodium	46.8	81.7	98.3	92.0	92.0	138.3	92.0	97.5	103.5
Mine Pit No. 3									
Temperature, F°	71.3	70.3	67.7	74.0	72.7	72.0	47.7	46.3	45.7
pH	8.3	8.4	8.3	8.5	8.4	8.2	8.2	8.7	8.7
Sulfate	668.0	688.0	788.0	683.0	703.0	740.0	858.0	1221.0	822.0
Conductivity*	3733.0	3667.0	4067.0	4200.0	4133.0	4267.0	3867.0	3800.0	3833.0
Calcium	239.0	246.0	283.0	309.0	300.0	327.0	306.0	312.0	303.0
Magnesium	426.0	422.0	488.0	555.0	463.0	488.0	517.0	480.0	533.0
Sodium	84.7	87.0	98.7	131.3	129.0	124.0	124.3	131.3	129.0

Table 12

DRINKING WATER QUALITY STANDARDS

DRINKING WATER STANDARDS OF THE U.S. PUBLIC HEALTH SERVICE(35)

A. General Constituents

Substance	Recommended Limits of Concentrations, mg/l	Mandatory Limits of Concentrations, mg/l
Alkyl benzene sulfonate (ABS)	0.5	--
Arsenic (As)	0.01	0.05
Barium (Ba)	--	1.0
Cadmium (Cd)	--	0.01
Carbon chloroform extract (CCE)	0.2	--
Chloride (Cl)	250	--
Chromium (hexavalent) ($Cr+^6$)	--	0.05
Copper (Cu)	1.0	--
Cyanide (CN)	0.01	0.2
Fluoride (F)	0.6-1.7	--
Iron (Fe)	0.3	--
Lead (Pb)	--	0.05
Manganese (Mn)	0.05	--
Nitrate (NO_3)*	45	--
Phenols	0.001	--
Selenium (Se)	--	0.01
Silver (Ag)	--	0.05
Sulfate (SO_4)	250	--
Total dissolved solids (TDS)	500	--
Zinc (Zn)	5	--

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*In areas in which the nitrate content of water is known to be in excess of the listed concentration, the public should be warned of the potential dangers of using the water for infant feeding.

Table 13

RECOMMENDED SURFACE WATER CRITERIA FOR PUBLIC WATER SUPPLIES(36)

Constituent or Characteristic	Permissible Criteria, mg/l	Desirable Criteria, mg/l
Ammonia	0.5 (as N)	<0.01
Arsenic	0.05	Absent
Barium	1.0	do
Boron	1.0	do
Cadmium	0.01	do
Chloride	250	<25
hromium, hexavalent	0.05	Absent
Copper	1.0	Virtually absent
issolved oxygen	≥4 (monthly mean)	Near saturation
	≥3 (individual sample)	
ron (filterable)	0.3	Virtually absent
Lead	0.05	Absent
anganese (filterable)	0.05	do
Nitrates plus nitrites	10 (as N)	Virtually absent
H (range)	6.0-8.5	Narrative
Selenium	0.01	Absent
ilver	0.05	do
Sulfate	250	<50
Total dissolved solids (filterable residue).	500	<200
Zinc	5	Virtually absent

10/4/73

Table 14

WATER QUALITY FOR LIVESTOCK

GUIDES FOR EVALUATING THE QUALITY OF WATER USED BY LIVESTOCK(37)

Quality Factor	Threshold Concentration,* mg/l	Limiting Concentration,+ mg/l
Total dissolved solids (TDS)	2500	5000
Cadmium	5	
Calcium	500	1000
Magnesium	250	500‡
Sodium	1000	2000‡
Arsenic	1	
Bicarbonate	500	500
Chloride	1500	3000
Fluoride	1	6
Nitrate	200	400
Nitrite	None	None
Sulfate	500	1000‡
Range of pH	6.0-8.5 pH	5.6-9.0 pH

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*Threshold values represent concentrations at which poultry or sensitive animals might show slight effects from prolonged use of such water. Lower concentrations are of little or no concern.

+Limiting concentrations based on interim criteria, South Africa. Animals in lactation or production might show definite adverse reactions.

‡Total magnesium compounds plus sodium sulfate should not exceed 50 percent of the total dissolved solids.

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                              WATER QUALITY ANALYSIS

          STATE  MONTANA                                    COUNTY  ROSEBUD
ATITUDE-LONGITUDE                                         LOCATION  01N 41E 08BBDB
    SAMPLE TYPE  WELL                                      LAB NO.  BA-1
GEOLOGICAL SOURCE                             SAMPLE OR BOTTLE NO.   8 BBDB
  DRAINAGE BASIN                          AGENCY AND STATION CODE
   DATE SAMPLED  03-19-73                 DEPTH WATER ENTERS WELL   340 FT
   TIME SAMPLED  1330                     SWL ABOVE(+) OR BELOW GS
  DATE ANALYZED  04-01-73                ALTITUDE OF SAMPLE POINT   3330
SAMPLE HANDLING  1211                             WATER FLOW RATE
 METHOD SAMPLED  PUMPED                          FLOW MEAS METHOD
ANITARY CONDITION                         PRINCIPAL USE OF WATER  DOMESTIC

        PROJECT  WESTINGHOUSE ELECTRIC ENV. COLSTRIP BY VAN VOAST
        REMARKS   LEO FARLEY /WNER, BASAL TONGUE RIVER SAND AQUIFER

    PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED
                 MG/L      MEQ/L                            MG/L      MEQ/L
 CALCIUM (CA)    14.0        0.700  BICARBONATE(HCO3)    413.        6.774
AGNESIUM (MG)     3.4        0.279    CARBONATE (CO3)     0.         0.0
  SODIUM (NA)   603.        26.230    HYDROXIDE  (OH)     0.         0.000
OTASSIUM  (K)     3.6        0.092     CHLORIDE  (CL)     7.9        0.224
OT. IRON (FE)      .65       0.035      SULFATE (SO4)   978.        20.362
ANGANESE (MN)      .02       0.001      NITRATE (NO3)      .1        0.002
ALUMINUM (AL)                           FLUORIDE   (F)     .4        0.021
SILICA (SIO2)     7.1                 PHOSPHATE (PO4)
                           ------                                   ------
         TOTAL CATIONS     27.337                  TOTAL ANIONS     27.383
      STANDARD DEVIATION OF CATION-ANION BALANCE   0.09 SIGMA

          LABORATORY PH      8.04  CARBONATE HARDNESS AS CACO3     49
      FIELD TEMPERATURE     13.0 C NON-CARB. HARDNESS AS CACO3      0
ALCULATED DISSOLVED SOLIDS 2031.6      TOTAL HARDNESS AS CACO3     49
EVAPORATED SOLIDS AT 105 C           TOTAL ALKALINITY AS CACO3    339
   SPECIFIC CONDUCTANCE IN           LANGLIER SATURATION INDEX
     MICROMHOS/CM AT 25 C  2610.0       RYSNAR STABILITY INDEX
   SODIUM ADSORPTION RATIO   37.5        TECH. CORROSION INDEX

                          ADDITIONAL PARAMETERS
      COPPER (CU)      <.02                    CADMIUM (CD)      <.01
     CHROMIUM (CR)     <.02                       ZINC (ZN)       .05
        LEAD (PB)      <.05                     NICKEL (NI)      <.04
     ARSENIC (AS)      <.002                  SELENIUM (SE)      <.005
     MERCURY (HG)       .0003                    BORON (B)       <.1
TAL PHOSPHATE(PO4)      .09


OTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE
  DILUTE SPECIFIC CONDUCTANCE                  PERCENT REACTANCE VALUES
EAS DSC      0.   CALC DSC   3160.     CA  MG  NA  K   CL  SO4 HCO3 CO3 NO3
   ERROR DSC   0.0                      3   1  96  0    1   74   25   0   0
ALYST  JCS                                     PROCESSING PROGRAM 72(REV3)
OTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER  BA-1
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F and S Analytical Services
2613 Kossuth Street
Butte, Montana 59701

Certified by ______, Chemist

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                                        WATER QUALITY ANALYSIS

                 STATE  MONTANA
    LATITUDE-LONGITUDE                                          COUNTY  ROSEBUD
           SAMPLE TYPE  WELL                                  LOCATION  02N 41E 21CAAC
     GEOLOGICAL SOURCE                                         LAB NO.  BA-2
        DRAINAGE BASIN                            SAMPLE OR BOTTLE NO.   21CAAC
          DATE SAMPLED  03-20-73               AGENCY AND STATION CODE
          TIME SAMPLED  1530                 DEPTH WATER ENTERS WELL      120 FT
         DATE ANALYZED  04-01-73            SWL ABOVE(+) OR BELOW GS      25.9
       SAMPLE HANDLING  1211               ALTITUDE OF SAMPLE POINT
        METHOD SAMPLED  PUMPED                       WATER FLOW RATE
    SANITARY CONDITION                              FLOW MEAS METHOD
                                             PRINCIPAL USE OF WATER   MULTIPLE

               PROJECT  WESTINGHOUSE ELECTRIC ENV. COLSTRIP BY VAN VOAST
               REMARKS   B AND R FOOD TOWN, SAND AQUIFER BELOW MCKAY BED

        PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED
                         MG/L       MEQ/L                                  MG/L        MEQ/L
      CALCIUM (CA)       163.        8.120  BICARBONATE(HCO3)              547.         8.958
    MAGNESIUM (MG)       153.       12.602     CARBONATE (CO3)             0.           0.000
       SODIUM (NA)       550.       23.925    HYDROXIDE   (OH)             0.           0.000
    POTASSIUM  (K)        10.3       0.264     CHLORIDE   (CL)             12.9         0.365
    TOT. IRON (FE)         1.3       0.070      SULFATE  (SO4)           1704.         35.477
    MANGANESE (MN)          .09      0.003      NITRATE  (NO3)               .2         0.003
     ALUMINUM (AL)                             FLUORIDE    (F)               .5         0.026
     SILICA (SIO2)        13.                PHOSPHATE  (PO4)
                                  ------                                              ------
               TOTAL CATIONS      44.934                          TOTAL ANIONS        44.829
           STANDARD DEVIATION OF CATION-ANION BALANCE -0.19 SIGMA

                     LABORATORY PH      7.43  CARBONATE HARDNESS AS CACO3    448
                 FIELD TEMPERATURE      10.0 C NON-CARB. HARDNESS AS CACO3   594
       CALCULATED DISSOLVED SOLIDS    3154.8       TOTAL HARDNESS AS CACO3   1042
        EVAPORATED SOLIDS AT 105 C               TOTAL ALKALINITY AS CACO3   448
         SPECIFIC CONDUCTANCE IN                 LANGLIER SATURATION INDEX
            MICROMHOS/CM AT 25 C      3460.0        RYSNAR STABILITY INDEX
         SODIUM ADSORPTION RATIO         7.4        TECH. CORROSION INDEX

                                     ADDITIONAL PARAMETERS
              COPPER (CU)         .02                  CADMIUM (CD)        <.01
            CHROMIUM (CR)        <.02                     ZINC (ZN)         .02
                LEAD (PB)         .1                    NICKEL (NI)         .04
             ARSENIC (AS)        <.002                SELENIUM (SE)        <.005
             MERCURY (HG)        <.0002                  BORON (B)          .45
    OTAL PHOSPHATE(PO4)          <.05


NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE
  DILUTE SPECIFIC CONDUCTANCE
MEAS DSC       0.   CALC DSC    5243.             PERCENT REACTANCE VALUES
     ERROR DSC   0.0                          CA  MG  NA  K   CL  SO4 HCO3 CO3 NO3
ANALYST  JES                                  18  28  53  1   1   79   20    0   0
                                                        PROCESSING PROGRAM 72(REV3)
NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER  BA-2
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                                 WATER QUALITY ANALYSIS

              STATE  MONTANA                                COUNTY  ROSEBUD
 LATITUDE-LONGITUDE                                       LOCATION  01N 41E 06CDAB
        SAMPLE TYPE  WELL                                  LAB NO.  BA-3
  GEOLOGICAL SOURCE                           SAMPLE OR BOTTLE NO.   8 COA
     DRAINAGE BASIN                        AGENCY AND STATION CODE
       DATE SAMPLED  03-18-73              DEPTH WATER ENTERS WELL   118 FT
       TIME SAMPLED  1100                 SWL ABOVE(+) OR BELOW GS   20.
      DATE ANALYZED  04-01-73             ALTITUDE OF SAMPLE POINT   3357
    SAMPLE HANDLING  1211                          WATER FLOW RATE
     METHOD SAMPLED  PUMPED                       FLOW MEAS METHOD
SANITARY CONDITION                        PRINCIPAL USE OF WATER  STOCK

           PROJECT  WESTINGHOUSE ELECTRIC ENV. COLSTRIP BY VAN VOAST
           REMARKS   LEO FARLEY, OWNER  ROSEBUD COAL AQUIFER

        PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED
                      MG/L       MEQ/L
                                                             MG/L        MEQ/L
   CALCIUM (CA)       72.          3.580  BICARBONATE(HCO3)  451.          7.386
 MAGNESIUM (MG)       74.          6.111    CARBONATE (CO3)   0.           0.0
    SODIUM (NA)       26.0         1.131    HYDROXIDE  (OH)   0.           0.000
 POTASSIUM  (K)        3.0         0.077    CHLORIDE   (CL)    5.9         0.166
TOT. IRON (FE)         .1          0.005     SULFATE (SO4)   147.          3.061
 MANGANESE (MN)        .02         0.001     NITRATE (NO3)     4.1         0.066
  ALUMINUM (AL)                              FLUORIDE   (F)     .25        0.013
 SILICA (SIO2)        19.                  PHOSPHATE (PO4)
                                 -------                                  -------
          TOTAL CATIONS          10.905                 TOTAL ANIONS       10.694
        STANDARD DEVIATION OF CATION-ANION BALANCE -0.77 SIGMA

             LABORATORY PH     7.51  CARBONATE HARDNESS AS CACO3    370
         FIELD TEMPERATURE     9.0 C NON-CARB. HARDNESS AS CACO3    113
CALCULATED DISSOLVED SOLIDS  802.1          TOTAL HARDNESS AS CACO3    483
EVAPORATED SOLIDS AT 105 C               TOTAL ALKALINITY AS CACO3    370
   SPECIFIC CONDUCTANCE IN               LANGLIER SATURATION INDEX
      MICROMHOS/CM AT 25 C   849.0            RYSNAR STABILITY INDEX
   SODIUM ADSORPTION RATIO     0.5           TECH. CORROSION INDEX

                           ADDITIONAL PARAMETERS
           COPPER (CU)       <.02
                                                CADMIUM (CD)      <.01
         CHROMIUM (CR)       <.02                  ZINC (ZN)       .10
             LEAD (PB)       <.05                NICKEL (NI)      <.04
          ARSENIC (AS)       <.002             SELENIUM (SE)      <.005
          MERCURY (HG)       <.0002                BORON (B)      <.1
TOTAL PHOSPHATE(PO4)          .08



NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE
   UNITS? SPECIFIC CONDUCTANCE                    PERCENT REACTANCE VALUES
MEAS EST      0.   CALC DIS   1098.      CA  MG  NA  K   CL  SO4 HCO3 CO3 NO3
    ERROR DSC    3.0                     33  56  10  1   2   29  69   0   1
ANALYST  LD
                                                   PROCESSING PROGRAM  (DIMEVS)
 NOTE. ALL CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER  BA-3
```

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                              WATER QUALITY ANALYSIS

              STATE  MONTANA
LATITUDE-LONGITUDE                                       COUNTY  ROSEBUD
       SAMPLE TYPE  STREAM                             LOCATION  01N 41E 03BBBC
 GEOLOGICAL SOURCE                                      LAB NO.  BA-4
    DRAINAGE BASIN                        SAMPLE OR BOTTLE NO.    3 BBBC
      DATE SAMPLED  03-20-73          AGENCY AND STATION CODE
      TIME SAMPLED  1330              DEPTH WATER ENTERS WELL
     DATE ANALYZED  04-01-73          SWL ABOVE(+) OR BELOW GS
   SAMPLE HANDLING  1211              ALTITUDE OF SAMPLE POINT    3248
    METHOD SAMPLED                             WATER FLOW RATE       0.1  CFS(E)
SANITARY CONDITION                           FLOW MEAS METHOD  FLOAT+TIME
                                       PRINCIPAL USE OF WATER  STOCK

           PROJECT   WESTINGHOUSE ELECTRIC ENV. COLSTRIP BY VAN VOAST
           REMARKS   EAST FORK ARMELLS CREEK SOUTH OF HIGHWAY 315

      PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED
                     MG/L       MEQ/L                                 MG/L         MEQ/L
    CALCIUM (CA)     195.        9.720  BICARBONATE(HCO3)          598.          9.797
  MAGNESIUM (MG)     219.       17.996    CARBONATE (CO3)          0.            0.0
     SODIUM (NA)     127.        5.524    HYDROXIDE  (OH)          0.            0.000
  POTASSIUM  (K)      12.2       0.312     CHLORIDE  (CL)          12.0          0.337
  TOT. IRON (FE)       .5        0.027      SULFATE (SO4)        1131.          23.547
  MANGANESE (MN)      1.8        0.066      NITRATE (NO3)            .2          0.003
   ALUMINUM (AL)                           FLUORIDE   (F)            .2          0.011
    SILICA (SIO2)     20.                 PHOSPHATE (PO4)
                                ------                                         ------
          TOTAL CATIONS        33.645                       TOTAL ANIONS       33.695
       STANDARD DEVIATION OF CATION-ANION BALANCE   0.08 SIGMA

              LABORATORY PH       7.52  CARBONATE HARDNESS AS CACO3    490
          FIELD TEMPERATURE       9.0 C NON-CARB. HARDNESS AS CACO3    906
CALCULATED DISSOLVED SOLIDS    2316.2          TOTAL HARDNESS AS CACO3  1396
 EVAPORATED SOLIDS AT 105 C                  TOTAL ALKALINITY AS CACO3  490
    SPECIFIC CONDUCTANCE IN                  LANGLIER SATURATION INDEX
      MICROMHOS/CM AT 25 C     2370.0          RYSNAR STABILITY INDEX
   SODIUM ADSORPTION RATIO        1.5           TECH. CORROSION INDEX

                              ADDITIONAL PARAMETERS
         COPPER (CU)       <.02                    CADMIUM (CD)       <.01
       CHROMIUM (CR)       <.02                       ZINC (ZN)        .01
           LEAD (PB)       <.05                     NICKEL (NI)       <.04
        ARSENIC (AS)       <.002                  SELENIUM (SE)       <.005
        MERCURY (HG)       <.0002                    BORON (B)         .45
OTAL PHOSPHATE(PO4)         .08


OTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE
  DILUTE SPECIFIC CONDUCTANCE                         PERCENT REACTANCE VALUES
EAS DSC        0.    CALC DSC    3831.    CA   MG   NA   K    CL   SO4 HCO3 CO3 NO3
   ERROR DSC    0.0                       29   54   16   1    1    70  20   0   0
NALYST  JES                                       PROCESSING PROGRAM 721-EV3)
NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER  BA-4
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                              WATER QUALITY ANALYSIS

             STATE  MONTANA
LATITUDE-LONGITUDE                                        COUNTY  ROSEBUD
       SAMPLE TYPE  CANAL                               LOCATION  02N 41E 34CAAD
GEOLOGICAL SOURCE                                        LAB NO.  BA-5
    DRAINAGE BASIN                        SAMPLE OR BOTTLE NO.    34CAAD
      DATE SAMPLED  03-20-73           AGENCY AND STATION CODE
      TIME SAMPLED  1630               DEPTH WATER ENTERS WELL
     DATE ANALYZED  04-01-73          SWL ABOVE(+) OR BELOW GS
   SAMPLE HANDLING  1211             ALTITUDE OF SAMPLE POINT   3222
    METHOD SAMPLED  BOTTLE                     WATER FLOW RATE          .05 CFS(E)
SANITARY CONDITION                            FLOW MEAS METHOD  FLOAT+TIME
                                         PRINCIPAL USE OF WATER

           PROJECT   WESTINGHOUSE ELECTRIC ENV. COLSTRIP BY VAN VOAST
           REMARKS   DITCH. LOCAL DRAINAGE ENTERING ARMELLS CREEK

       PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED
                      MG/L      MEQ/L                              MG/L       MEQ/L
   CALCIUM (CA)       138.       6.900  BICARBONATE(HCO3)         346.        5.670
 MAGNESIUM (MG)       132.      10.824    CARBONATE (CO3)           0.        0.0
    SODIUM (NA)       106.       4.611    HYDROXIDE  (OH)           0.        0.000
 POTASSIUM  (K)         9.3      0.238    CHLORIDE   (CL)          10.1       0.285
 TOT. IRON (FE)          .1      0.005     SULFATE (SO4)          795.       16.552
 MANGANESE (MN)         .29      0.011     NITRATE (NO3)             .5       0.008
  ALUMINUM (AL)                           FLUORIDE    (F)            .2       0.011
  SILICA (SIO2)        7.1                PHOSPHATE (PO4)
                                -------                                     -------
            TOTAL CATIONS      22.569                       TOTAL ANIONS   22.5[illegible]
         STANDARD DEVIATION OF CATION-ANION BALANCE -0.12 SIGMA

            LABORATORY PH      7.61  CARBONATE HARDNESS AS CACO3     284
         FIELD TEMPERATURE     9.0 C NON-CARB. HARDNESS AS CACO3     607
CALCULATED DISSOLVED SOLIDS  1544.9       TOTAL HARDNESS AS CACO3    891
 EVAPORATED SOLIDS AT 105 C              TOTAL ALKALINITY AS CACO3   284
   SPECIFIC CONDUCTANCE IN               LANGLIER SATURATION INDEX
    MICROMHOS/CM AT 25 C     1725.0          RYSNAR STABILITY INDEX
   SODIUM ADSORPTION RATIO      1.5           TECH. CORROSION INDEX

                              ADDITIONAL PARAMETERS
       COPPER (CU)        <.02
                                             CADMIUM (CD)        <.01
     CHROMIUM (CR)        <.02
                                               ZINC (ZN)          .21
         LEAD (PB)        <.05
                                             NICKEL (NI)         <.04
      ARSENIC (AS)        <.002
                                           SELENIUM (SE)         <.005
      MERCURY (HG)        <.0002
                                                BORON (B)          .29
TOTAL PHOSPHATE(PO4)       .12


ALL PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE
  DILUTE SPECIFIC CONDUCTANCE                  PERCENT REACTANCE VALUES
LAB S.C.      0.   CALC DSC    2000.    CA  MG  NA  K   CL  SO4 HCO3 CO3 NO3
    ERROR DSC    0.0                    31  48  20  1   1   73  25    0   [illegible]
[illegible]                                          PROCESSING PROGRAM 72(REV3)
NOTE. IF CORRESPONDENCE RELATED TO THIS ANALYSES , REFER TO NUMBER  BA-5
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       2417 Research Street
       Butte, Montana    59701                  Certified by                , Chemist
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                                WATER QUALITY ANALYSIS

                STATE  MONTANA                               COUNTY  ROSEBUD
   LATITUDE-LONGITUDE                                      LOCATION  01N 41E 03AABD
          SAMPLE TYPE  LAKE                                 LAB NO.  BA-6
    GEOLOGICAL SOURCE                          SAMPLE OR BOTTLE NO.   3AABD
       DRAINAGE BASIN                       AGENCY AND STATION CODE
         DATE SAMPLED  03-20-73             DEPTH WATER ENTERS WELL
         TIME SAMPLED  1700                 SWL ABOVE(+) OR BELOW GS
        DATE ANALYZED  04-01-73             ALTITUDE OF SAMPLE POINT  3235
      SAMPLE HANDLING  1211                         WATER FLOW RATE
       METHOD SAMPLED  BOTTLE                      FLOW MEAS METHOD
  SANITARY CONDITION                         PRINCIPAL USE OF WATER

              PROJECT  WESTINGHOUSE ELECTRIC ENV. COLSTRIP BY VAN VOAST
              REMARKS    COLSTRIP SWIMMING HOLE, PIT NUMBER ONE

       PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED
                     MG/L     MEQ/L                              MG/L      MEQ/L
     CALCIUM (CA)    105.        5.260  BICARBONATE(HCO3)      285.        4.675
   MAGNESIUM (MG)    541.       44.495    CARBONATE (CO3)        0.        0.0
      SODIUM (NA)    225.        9.787    HYDROXIDE  (OH)        0.        0.000
  POTASSIUM   (K)     19.0       0.486     CHLORIDE  (CL)       23.        0.640
  TOT. IRON  (FE)       .15      0.003      SULFATE (SO4)     2630.       54.757
  MANGANESE  (MN)       .22      0.008      NITRATE (NO3)         .4       0.006
    ALUMINUM (AL)                          FLUORIDE   (F)         .1       0.005
    SILICA (SIO2)      2.9                PHOSPHATE (PO4)
                                ------                                    ------
           TOTAL CATIONS       60.045                      TOTAL ANIONS  60.083
         STANDARD DEVIATION OF CATION-ANION BALANCE   0.04 SIGMA

                 LABORATORY PH      7.97  CARBONATE HARDNESS AS CACO3   234
             FIELD TEMPERATURE      6.5 C NON-CARB. HARDNESS AS CACO3  2297
  CALCULATED DISSOLVED SOLIDS   3832.0        TOTAL HARDNESS AS CACO3  2531
    EVAPORATED SOLIDS AT 105 C              TOTAL ALKALINITY AS CACO3   234
       SPECIFIC CONDUCTANCE IN              LANGLIER SATURATION INDEX
          MICROMHOS/CM AT 25 C  3880.0         RYSNAR STABILITY INDEX
       SODIUM ADSORPTION RATIO     2.0          TECH. CORROSION INDEX

                                 ADDITIONAL PARAMETERS
            COPPER (CU)      <.02                     CADMIUM (CD)      <.01
          CHROMIUM (CR)      <.02                        ZINC (ZN)       .01
              LEAD (PB)       .16                      NICKEL (NI)       .06
           ARSENIC (AS)      <.002                   SELENIUM (SE)      <.005
           MERCURY (HG)      <.0002                     BORON (B)        .26
 OTAL PHOSPHATE(PO4)          .07


NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE
   DILUTE SPECIFIC CONDUCTANCE                     PERCENT REACTANCE VALUES
MEAS DSC       0.    CALC DSC .  7158.     CA   MG   NA   K    CL   SO4 HCO3 CO3 NO3
     ERROR DSC    0.0                       9   74   16   1    1    91    8    0   0
ANALYST   JLS                                          PROCESSING PROGRAM 72(REV3)
 NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER  BA-6
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                              WATER QUALITY ANALYSIS

            STATE  MONTANA
LATITUDE-LONGITUDE                                            COUNTY  ROSEBUD
       SAMPLE TYPE  WASTE                                   LOCATION  01N 42E 17BC
 GEOLOGICAL SOURCE                                           LAB NO.  BA-7
    DRAINAGE BASIN                             SAMPLE OR BOTTLE NO.   17BC
      DATE SAMPLED  03-24-73                AGENCY AND STATION CODE
      TIME SAMPLED  1600                   DEPTH WATER ENTERS WELL
     DATE ANALYZED  04-01-73              SWL ABOVE(+) OR BELOW GS
   SAMPLE HANDLING  1211                  ALTITUDE OF SAMPLE POINT   3237
    METHOD SAMPLED  BOTTLE                         WATER FLOW RATE
SANITARY CONDITION                                FLOW MEAS METHOD
                                          PRINCIPAL USE OF WATER  UNUSED

          PROJECT  WESTINGHOUSE ELECTRIC ENV. COLSTRIP BY VAN VOAST
          REMARKS  PIT NUMBER SIX, DRAINAGE FROM COAL BED

       PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED
                    MG/L      MEQ/L                              MG/L      MEQ/L
   CALCIUM (CA)     45.        2.240  BICARBONATE(HCO3)         244.        3.999
 MAGNESIUM (MG)     47.        3.883    CARBONATE (CO3)           0.        0.0
    SODIUM (NA)     19.8       0.861    HYDROXIDE  (OH)           0.        0.000
 POTASSIUM  (K)      2.8       0.072     CHLORIDE  (CL)           3.3       0.093
 TOT. IRON (FE)       .1       0.005      SULFATE (SO4)         104.        2.165
 MANGANESE (MN)      .05       0.002      NITRATE (NO3)          47.4       0.764
  ALUMINUM (AL)                          FLUORIDE   (F)            .2       0.011
  SILICA (SIO2)     21.                 PHOSPHATE (PO4)
                               -----                                       -----
          TOTAL CATIONS        7.063                        TOTAL ANIONS   7.032
        STANDARD DEVIATION OF CATION-ANION BALANCE -0.14 SIGMA

              LABORATORY PH      8.19  CARBONATE HARDNESS AS CACO3    200
          FIELD TEMPERATURE     12.0 C NON-CARB. HARDNESS AS CACO3    108
 ALCULATED DISSOLVED SOLIDS    534.7         TOTAL HARDNESS AS CACO3  308
 EVAPORATED SOLIDS AT 105 C                TOTAL ALKALINITY AS CACO3  200
    SPECIFIC CONDUCTANCE IN                LANGLIER SATURATION INDEX
        MICROMHOS/CM AT 25 C   624.0          RYSNAR STABILITY INDEX
    SODIUM ADSORPTION RATIO      0.5           TECH. CORROSION INDEX

                             ADDITIONAL PARAMETERS
        COPPER (CU)        <.02
      CHROMIUM (CR)        <.02                      CADMIUM (CD)     <.01
          LEAD (PB)        <.05                         ZINC (ZN)     <.01
       ARSENIC (AS)        <.002                      NICKEL (NI)     <.04
       MERCURY (HG)        <.0002                   SELENIUM (SE)     <.005
TAL PHOSPHATE(PO4)          .13                         BORON (B)      .21


TE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE
  DILUTE SPECIFIC CONDUCTANCE
 AS DSC        0.    CALC DSC     741.                PERCENT REACTANCE VALUES
    ERROR DSC    0.0                       CA  MG  NA  K   CL  SO4 HCO3 CO3 NO3
ALYST  RAF                                 32  55  12  1   1   31   57   0  11
OTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER  BA-7
                                                    PROCESSING PROGRAM 72(REV1)
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                              WATER QUALITY ANALYSIS

           STATE  MONTANA                             COUNTY  ROSEBUD
LATITUDE-LONGITUDE                                  LOCATION  02N 41E 34CDAD
     SAMPLE TYPE  WELL                               LAB NO.  BA-1
GEOLOGICAL SOURCE                        SAMPLE OR BOTTLE NO.  SPOIL 2
   DRAINAGE BASIN                     AGENCY AND STATION CODE
    DATE SAMPLED  03-23-73            DEPTH WATER ENTERS WELL     27 FT
    TIME SAMPLED                     SWL ABOVE(+) OR BELOW GS    23.8
   DATE ANALYZED  04-01-73           ALTITUDE OF SAMPLE POINT   3253
 SAMPLE HANDLING  1211                        WATER FLOW RATE
  METHOD SAMPLED  FCERST                      FLOW MEAS METHOD
SANITARY CONDITION                   PRINCIPAL USE OF WATER  UNUSED

         PROJECT  WESTINGHOUSE ELECTRIC ENV. COLSTRIP BY VAN VOAST
         REMARKS  PIT NUMBER ONE, SPOIL-BANK HOLE NO. 2

     PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED
                    MG/L      MEQ/L                              MG/L      MEQ/L
  CALCIUM (CA)      481.       24.000  BICARBONATE(HCO3)       697.       11.417
 MAGNESIUM (MG)     748.       61.524    CARBONATE (CO3)        0.         0.0
   SODIUM (NA)       23.4       1.018    HYDROXIDE  (OH)        0.         0.000
 POTASSIUM  (K)      11.1       0.284     CHLORIDE  (CL)        3.2        0.092
 TOT. IRON (FE)        .3       0.016      SULFATE (SO4)     3640.        75.735
 MANGANESE (MN)       4.7       0.171      NITRATE (NO3)         .3        0.005
  ALUMINUM (AL)                           FLUORIDE   (F)         .2        0.011
  SILICA (SIO2)     17.                  PHOSPHATE (PO4)
                               ------                                     ------
         TOTAL CATIONS         87.013                    TOTAL ANIONS     87.309
       STANDARD DEVIATION OF CATION-ANION BALANCE  0.20 SIGMA

           LABORATORY PH        7.32  CARBONATE HARDNESS AS CACO3    571
       FIELD TEMPERATURE              NON-CARB. HARDNESS AS CACO3   3749
CALCULATED DISSOLVED SOLIDS   5625.7      TOTAL HARDNESS AS CACO3   4320
  EVAPORATED SOLIDS AT 105 C            TOTAL ALKALINITY AS CACO3    571
     SPECIFIC CONDUCTANCE IN            LANGLIER SATURATION INDEX
       MICROMHOS/CM AT 25 C   4860.0       RYSNAR STABILITY INDEX
     SODIUM ADSORPTION RATIO     0.2        TECH. CORROSION INDEX

                             ADDITIONAL PARAMETERS
         COPPER (CU)        .02                      CADMIUM (CD)      <.01
       CHROMIUM (CR)        .02                         ZINC (ZN)       .19
           LEAD (PB)        .19                       NICKEL (NI)       .14
         ARSENIC (AS)      <.002                    SELENIUM (SE)     <.005
         MERCURY (HG)      <.0002                      BORON (B)        .17
OTAL PHOSPHATE(PO4)         .13

NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELLED TR-TOTAL RECOVERABLE
   DILUTE SPECIFIC CONDUCTANCE                    PERCENT REACTANCE VALUES
MEAS DSC        0.    CALC DSC   10290.     CA  MG  NA   K   CL  SO4 HCO3 CO3 NO3
     ERROR DSC   0.0                        28  71   1   0    0   87  13    0   0
ANALYST  RAF                                      PROCESSING PROGRAM 72(REV1)
 NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER  BA-1
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Butte, Montana 59701

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                                    WATER QUALITY ANALYSIS
                 STATE  MONTANA
    LATITUDE-LONGITUDE                                              COUNTY  ROSEBUD
           SAMPLE TYPE  WELL                                      LOCATION  02N 41E 35BCCD
     GEOLOGICAL SOURCE                                             LAB NO.  BA-9
        DRAINAGE BASIN                                SAMPLE OR BOTTLE NO.  SPOIL 3
          DATE SAMPLED  03-23-73                  AGENCY AND STATION CODE
          TIME SAMPLED                            DEPTH WATER ENTERS WELL
         DATE ANALYZED  04-01-73                 SWL ABOVE(+) OR BELOW GS    16.6
       SAMPLE HANDLING  1211                     ALTITUDE OF SAMPLE POINT   3257
        METHOD SAMPLED  FOERST                            WATER FLOW RATE
    SANITARY CONDITION                                    FLOW MEAS METHOD
                                                 PRINCIPAL USE OF WATER  UNUSED
              PROJECT  WESTINGHOUSE ELECTRIC ENV. COLSTRIP BY VAN VOAST
              REMARKS  PIT NUMBER ONE, SPOIL-BANK HOLE NO. 3
         PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED
                        MG/L       MEQ/L
      CALCIUM (CA)      347.                                          MG/L       MEQ/L
    MAGNESIUM (MG)      280.       17.300  BICARBONATE(HCO3)          500.
       SODIUM (NA)       52.4      23.025    CARBONATE (CO3)           0.        8.198
    POTASSIUM  (K)       14.6       2.279    HYDROXIDE  (OH)           0.        0.0
    TOT. IRON (FE)         .4       0.374     CHLORIDE  (CL)          11.5       0.000
    MANGANESE (MN)         .32      0.021      SULFATE (SO4)        1650.        0.323
     ALUMINUM (AL)                  0.012      NITRATE (NO3)                    34.353
     SILICA (SIO2)       24.                   FLUORIDE  (F)            .5       0.008
                                              PHOSPHATE (PO4)            .1       0.005
                                  -------
          TOTAL CATIONS           43.011                                       -------
       STANDARD DEVIATION OF CATION-ANION BALANCE -0.16 SIGMA   TOTAL ANIONS    42.337
             LABORATORY PH         7.19  CARBONATE HARDNESS AS CACO3   410
           FIELD TEMPERATURE             NON-CARB. HARDNESS AS CACO3  1614
  CALCULATED DISSOLVED SOLIDS   2880.6       TOTAL HARDNESS AS CACO3  2025
   EVAPORATED SOLIDS AT 105 C              TOTAL ALKALINITY AS CACO3   410
      SPECIFIC CONDUCTANCE IN              LANGLIER SATURATION INDEX
        MICROMHOS/CM AT 25 C    2848.0       RYSNAR STABILITY INDEX
     SODIUM ADSORPTION RATIO       0.5         TECH. CORROSION INDEX
                                 ADDITIONAL PARAMETERS
           COPPER (CU)      .03
         CHROMIUM (CR)     <.02                     CADMIUM (CD)      <.01
             LEAD (PB)      .13                        ZINC (ZN)       .84
          ARSENIC (AS)     <.002                     NICKEL (NI)       .06
          MERCURY (HG)     <.0002                  SELENIUM (SE)     <.005
 TOTAL PHOSPHATE(PO4)       .10                        BORON (B)       .96

NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE
   DILUTE SPECIFIC CONDUCTANCE                          PERCENT REACTANCE VALUES
MEAS DSC       0.   CALC DSC   5033.     CA  MG  NA  K   CL  SO4 HCO3 CO3 NO3
    ERROR DSC   0.0                      40  54   5  1    1   80  19   0   0
ANALYST  RAF                                          PROCESSING PROGRAM 72(REV3)
NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER  BA-9
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F and S Analytical Services
2613 Kossuth Street
Butte, Montana 59701

Certified by ____________________, Chemist

WATER QUALITY ANALYSIS

STATE	MONTANA	COUNTY	ROSEBUD
LATITUDE-LONGITUDE		LOCATION	02N 41E 35CBAA
SAMPLE TYPE	WELL	LAB NO.	8A-10
GEOLOGICAL SOURCE		SAMPLE OR BOTTLE NO.	SPOIL 4
DRAINAGE BASIN		AGENCY AND STATION CODE	
DATE SAMPLED	03-23-73	DEPTH WATER ENTERS WELL	
TIME SAMPLED		SWL ABOVE(+) OR BELOW GS	39.0
DATE ANALYZED	04-01-73	ALTITUDE OF SAMPLE POINT	~~3252~~ 3273 (w.u.u.)
SAMPLE HANDLING	1211	WATER FLOW RATE	
METHOD SAMPLED	FOERST	FLOW MEAS METHOD	
SANITARY CONDITION		PRINCIPAL USE OF WATER	UNUSED

PROJECT WESTINGHOUSE ELECTRIC ENV. COLSTRIP BY VAN VOAST
REMARKS PIT NUMBER ONE, SPOIL-BANK HOLE NO. 4

PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED

	MG/L	MEQ/L		MG/L	MEQ/L
CALCIUM (CA)	380.	18.940	BICARBONATE(HCO3)	973.	15.943
MAGNESIUM (MG)	477.	39.209	CARBONATE (CO3)	0.	0.0
SODIUM (NA)	81.3	3.537	HYDROXIDE (OH)	0.	0.000
POTASSIUM (K)	13.5	0.346	CHLORIDE (CL)	11.9	0.336
TOT. IRON (FE)	1.1	0.059	SULFATE (SO4)	2212.	46.054
MANGANESE (MN)	5.0	0.182	NITRATE (NO3)	1.1	0.018
ALUMINUM (AL)			FLUORIDE (F)	.1	0.005
SILICA (SIO2)	19.		PHOSPHATE (PO4)		
TOTAL CATIONS		62.272	TOTAL ANIONS		62.350

STANDARD DEVIATION OF CATION-ANION BALANCE 0.08 SIGMA

LABORATORY PH	7.04	CARBONATE HARDNESS AS CACO3	798
FIELD TEMPERATURE		NON-CARB. HARDNESS AS CACO3	2134
CALCULATED DISSOLVED SOLIDS	4174.2	TOTAL HARDNESS AS CACO3	2932
EVAPORATED SOLIDS AT 105 C		TOTAL ALKALINITY AS CACO3	798
SPECIFIC CONDUCTANCE IN MICROMHOS/CM AT 25 C	3860.0	LANGLIER SATURATION INDEX	
		RYSNAR STABILITY INDEX	
SODIUM ADSORPTION RATIO	0.7	TECH. CORROSION INDEX	

ADDITIONAL PARAMETERS

COPPER (CU)	.03	CADMIUM (CD)	<.01
CHROMIUM (CR)	.02	ZINC (ZN)	.45
LEAD (PB)	.19	NICKEL (NI)	.10
ARSENIC (AS)	<.002	SELENIUM (SE)	<.005
MERCURY (HG)	<.0002	BORON (B)	.46
TAL PHOSPHATE(PO4)	.09		

OTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE

DILUTE SPECIFIC CONDUCTANCE				PERCENT REACTANCE VALUES								
EAS DSC	0.	CALC DSC	7135.	CA	MG	NA	K	CL	SO4	HCO3	CO3	NO3
ERROR DSC	0.0			31	63	6	1	1	74	26	0	0

ALYST RAF PROCESSING PROGRAM 72(REV3)

NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER 8A-10

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Butte, Montana 59701

Certified by G. A. Frenke, Chemist

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                                   WATER QUALITY ANALYSIS

              STATE  MONTANA
LATITUDE-LONGITUDE                                           COUNTY  ROSEBUD
        SAMPLE TYPE  WELL                                  LOCATION  01N 41E 03AA38
  GEOLOGICAL SOURCE                                         LAB NO.  BA-11
     DRAINAGE BASIN                       SAMPLE OR BOTTLE NO.  SPOIL 5
       DATE SAMPLED  03-23-73            AGENCY AND STATION CODE
       TIME SAMPLED                      DEPTH WATER ENTERS WELL
      DATE ANALYZED  04-01-73           SWL ABOVE(+) OR BELOW GS   26.2
    SAMPLE HANDLING  1211               ALTITUDE OF SAMPLE POINT  3264
     METHOD SAMPLED  FOERST                      WATER FLOW RATE
 SANITARY CONDITION                             FLOW MEAS METHOD
                                       PRINCIPAL USE OF WATER  UNUSED

            PROJECT  WESTINGHOUSE ELECTRIC ENV. COLSTRIP BY VAN VOAST
            REMARKS  PIT NUMBER ONE. SPOIL-BANK HOLE NO. 5

       PARAMETERS REPORTED IN MILLIGRAMS PER LITER EXCEPT AS INDICATED
                       MG/L       MEQ/L
                                                                 MG/L         MEQ/L
    CALCIUM (CA)      333.         16.600  BICARBONATE(HCO3)    629.         10.307
  MAGNESIUM (MG)      317.         26.083     CARBONATE (CO3)     0.           0.0
     SODIUM (NA)       57.7         2.510     HYDROXIDE  (OH)     0.           0.000
  POTASSIUM  (K)       12.0         0.307      CHLORIDE  (CL)    13.6          0.385
  TOT. IRON (FE)         .15        0.008       SULFATE (SO4)  1668.          34.721
  MANGANESE (MN)        2.2         0.030       NITRATE (NO3)     4.4          0.071
   ALUMINUM (AL)                               FLUORIDE   (F)      .1          0.005
   SILICA (SIO2)      21.                    PHOSPHATE (PO4)
                                 -------                                      -------
          TOTAL CATIONS          45.538                    TOTAL ANIONS       45.498
       STANDARD DEVIATION OF CATION-ANION BALANCE -0.11 SIGMA

              LABORATORY PH        6.94  CARBONATE HARDNESS AS CACO3    516
          FIELD TEMPERATURE              NON-CARB. HARDNESS AS CACO3   1631
 CALCULATED DISSOLVED SOLIDS    3058.0       TOTAL HARDNESS AS CACO3   2147
  EVAPORATED SOLIDS AT 105 C                TOTAL ALKALINITY AS CACO3   516
     SPECIFIC CONDUCTANCE IN                LANGLIER SATURATION INDEX
        MICROMHOS/CM AT 25 C    2594.0          RYSNAR STABILITY INDEX
    SODIUM ADSORPTION RATIO        0.5          TECH. CORROSION INDEX

                                  ADDITIONAL PARAMETERS
          COPPER (CU)       <.02                         CADMIUM (CD)      <.01
        CHROMIUM (CR)       <.02                            ZINC (ZN)       .27
            LEAD (PB)        .14                          NICKEL (NI)       .08
         ARSENIC (AS)       <.002                       SELENIUM (SE)      <.005
         MERCURY (HG)       <.0002                         BORON (B)       1.2
 OTAL PHOSPHATE(PO4)         .15


NOTE. PARAMETERS ARE TOTAL DISSOLVED UNLESS LABELED TR-TOTAL RECOVERABLE
   DILUTE SPECIFIC CONDUCTANCE                        PERCENT REACTANCE VALUES
MEAS DSC       0.    CALC DSC    5274.      CA  MG  NA  K   CL  SO4 HCO3 CO3 NO3
    ERROR DSC    0.0                        36  57   6  1    1   76  23    0   0
ANALYST  RAF
 NOTE. IN CORRESPONDENCE RELATED TO THIS ANALYSIS REFER TO NUMBER  BA-11
                                                    PROCESSING PROGRAM 72(REV1)
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(2)(e)(i) LOCATIONS OF KNOWN WELLS

Information on wells at and close to the 1974 mining area was compiled from: (1) data from the U. S. Geological Survey Office in Billings, Montana, presently conducting a well inventory in the Colstrip area, (2) records of groundwater rights of the Department of Natural Resources and Conservation in Helena, Montana, (3) data collected by Montana Bureau of Mining and Geology personnel presently conducting a hydrological study at this area and (4) the hydrological study conducted in March 1973 by a competant hydrologist for Westinghouse Environmental Systems.

As required by the regulations, data was obtained on wells located three miles downstream of the 1974 mining areas and one mile in all directions. Sections 1, 2, 3, 4, 8, 9, 10, 11, 12, 13, 14 and 24 in Township 1N and Range 41E, sections 32, 33, 34, 35 and 36 in Township 1N and Range 42E, and sections 6, 7, 8, 17, 18, 19 and 20 in Township 2N and Range 41E were considered. The known wells to be located in these sections as well as ownership, use, production, depth, aquifer and possibility of being affected by the mining operation are listed in Table 15.

Only one spring was located in this area. It is also listed in Table 15.

(2)(e)(ii) ALTERNATE WATER SUPPLIES

Regulation (2e) contains a detailed description of the hydrogeologic units in the Colstrip area with special emphasis on production and water quality of the local aquifers.

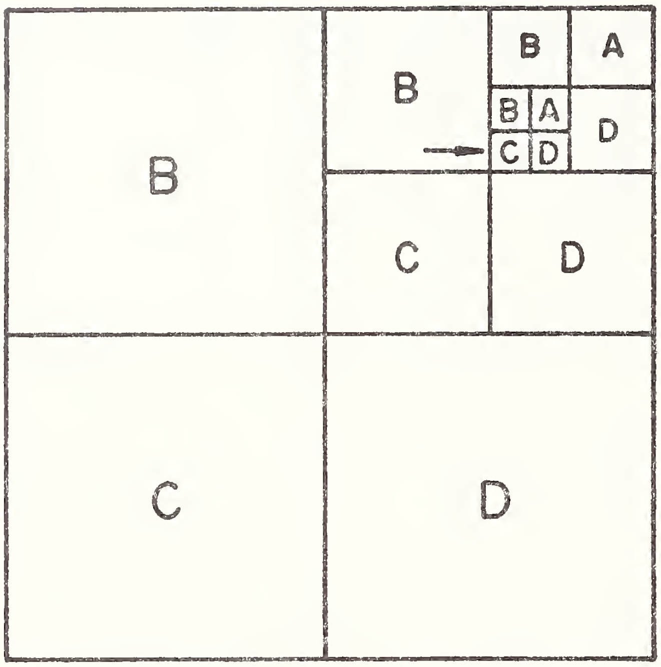
Three important aquifers are located in the upper 200 feet of the Colstrip mining area: the Rosebud coal seam, the McKay coal seam, and when located below the water table, the sandstone bed overlying the Rosebud seam is a significant aquifer. In the Tongue River member sandstone beds, below the coal seams, lie several productive aquifers from which the town of Colstrip and many farmers draw their water supply.

The McKay coal seam and the deeper sandstone aquifers can replace the affected shallow ground waters and the Rosebud aquifer. Strip mining operations should not affect these aquifers (refer to impact of strip mining on groundwater in the Environmental Analysis).

As shown in 2(e)(i) only very few wells will be affected by the 1974 mining in the area, and the deeper aquifers can serve as alternate water suppliers.

Key for Table 15

1. Locations are designated by succesive quadrants:



The area indicated is located AACC.

X denotes no information in record.

2. On Arnells Creek Floodplain
3. Well water source.
   A - Above the Rosebud seam aquifier.
   R - Within the Rosebud seam aquifier.
   B - Below the Rosebud seam aquifier.
   O - Outside Rosebud seam.
4. Margin of mining area is 3 miles downdip and 1 mile in all other directions; or 1 mile downdip of lower boundary of Rosebud coal seam.
5. Wells are considered affected by mining if they are:
   a. within one mile of the affected area of mining.
   b. in the Rosebud seam within three miles downdip of the affected area and one mile in all other directions.
   c. within 1 mile downdip at the lower boundary of the Rosebud seam.
6. NR denotes "not in record".
7. (*) In affected area.
8. (†) Wells are in Rosebud Creek Floodplain
9. 2 miles downdip of affected area.

TABLE 15

KNOWN WELLS AND SPRINGS

Township	Range	Section	Location	Owner	Use of Water	Depth Of Well Feet	Depth To Water Feet	Production gpm	Power	Aquifer	In Margin	Affected by Mining
2N	41E	8	CAAA	Duncan McDonald		NR	NR	5	elec.	NR	N	N
2N	41E	6	BBBX	Tom Hagerman		165	147	4	NR	B	N	N
2N	41E	6	BBBX	Tom Hagerman		121	30	4	gas	B	N	N
1N	41E	2	DBXX	No. Pac. Railway Co.··	Livestock	141	75	14	NP	B	Y	Y*
1N	41E	3	BBXX	No. Pac. Railway Co.	Livestock	55	45	25	NR	B	Y	N
1N	41E	3	DCXX	No. Pac. Railway Co.	Livestock	100	10	25	NR	NR	Y	Y**
1N	41E	3	CDDD	Jim Snider;visited †		86	66	2.5	elec.	NR	Y	Y**
1N	41E	3	BBBB	Jim Snider		NR	NR	NR	NR	NR	Y	Y
1N	41E	12	CBDB	Duke McRae; visited†		NR	NR	NR	elec.	NR	Y	Y
1N	41E	13	CDCD	Jim Snider; visited†		200	107	8	elec.	B	N	N
1N	41E	24	CCAD	James Snider		spring		small	NR	A	N	N
1N	41E	24	DDBB	James Snider; visited†	Not on Map	12		NR		A	N	N
1N	42E	32	DDAC	Lee F. Cartwright	Livestock	80	55	6	elec.	0	N	N
1N	42E	32	DADD	Duke McRae ;visited†	On Map	34	NR	NR	Deep well pump	NR	N	N
1N	42E	33	BDDB	Higham Cattle Co.	Livestock	91	57	14	elec.	B	N	N
1N	42E	33	CCCC	Lee E. Cartwright	Livestock, House	230	226	16	elec.	B	N	N
1N	42E	33	ADBC	Wally McRae: visited†		42	21	13	elec.	0	N	N
1N	42E	34	BDDB	Wally McRae; visited†		NR	NR	NR	NR	NR	N	N
1N	42E	34	ACAB	Wally McRae; visited†		275	8	NR	elec.	B	N	N
1N	42E	34	BACC	Dora Mees,	Livestock	40	NR	NR	NR	NR	N	N
1N	42E	34	CCDA	Dora Mees,	House,livestock	160	NR	NR	NR	NR	N	N
1N	42E	34	ACCA	Higham Cattle Co.	Household	275	9	NR	elec.	NR	N	N
1N	42E	34	ACCA	Higham Cattle Co.	Stock&House	50	48	25	elec.	NR	N	N

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* In affected area.

** Probably will be affected.

† Visited by Mr. Hopkins, U.S.G.S.

2(f) MONITORING PROGRAMS OF STRIP MINING IMPACT ON GROUNDWATER

Western Energy Company is presently partially sponsoring a long term comprehensive hydrological study conducted by the Montana Bureau of Mines and Geology. The project began on July 1, 1973. Monitoring the quantity and quality of the groundwater at the mining area is part of this program.

The contract between Western Energy Company and the Montana Bureau of Mines and Geology contains the following details regarding the program's procedures:

Procedures for the first two years of the proposed study are as follows:

A. Field procedures:

1. General hydrologic reconnaissance of the Colstrip area.
2. General inventory of existing wells in the area.
3. Collection of water samples from selected wells and stream locations.
4. Installation of weirs and monitor equipment at selected stream locations.
5. Installation of observation wells at selected locations.
6. Installation of recorders and shelters on selected observation wells.

B. Office procedures:

1. Examination of available water data (county records, well driller's logs).
2. Analysis of water samples.
3. Compilation of data.
4. Completion of initial report.

Procedures during the third year will include monthly collection of water samples at selected locations and collection of records from monitored weirs and wells. During the third year of work, plans and budgets for succeeding years of sampling and monitoring will be negotiated by Western Energy Company and the project representative if deemed necessary.

2(g) DESCRIPTION OF MATERIALS HANDLED DURING MINING

The physical and chemical analyses, description of the overburden and topsoil, and artificial weathering and plant growth data are given in S10300 2(a).

Water infiltration rate is defined as the flux passing through the surface and flowing into the profile.(1) Water infiltration capacity is defined as the flux which the soil profile can absorb through its surface when it is maintained in contact with water at atmospheric pressure.(1) Water infiltration depends upon ground surface character, soil permeability and crop cover.

Attempts were made to determine the actual water infiltration in the 1974 mining area.(2) However the violent weather conditions in the area destroyed the instruments and no data are available as yet. Special instruments are designed to sustain the climatic conditions and measurements are planned for the near future. As soon as data is obtained it will be forwarded to the Montana Department of State Lands.

In the Colstrip vicinity infiltration rates include: Class 1 with a rate of less than 0.05 in/hr; Class 2, 0.05 to 0.2 in/hr; and Class 3, 0.2 to 0.6 in/hr.(3) Materials handled during mining and backfilling operations will be disturbed, permeability will be increased and the soil surface will be manipulated to provide water-catchment depressions. The water infiltration rate during mining and backfilling is estimated to range between 0.2 and 0.6 inches per hour at saturation.

Infiltration tests on undisturbed soils were successful at the Big Sky Mine. Table 16 lists the values obtained at this area (5 miles from area A, 3 miles from area E and 2.5 miles from Pit 6).

Table 16

Infiltration Tests at Big Sky Mine(2)

Depth	Time		Moisture at Field Capacity
Feet	Min.	Sec.	%
2 - 4	11	05	28.2
4 - 6	12	25	28.3
6 - 8	11	25	27.3
8 - 10	13	05	31.6
10 - 12	11	15	24.8
14 - 16	13	55	35.3
16 - 18	12	00	27.5
18 - 20	12	20	28.9
22 - 24	11	50	26.2
26 - 28	13	30	31.4
30 - 31	46	00	24.2
31 - 32	3	00	1.3
34 - 36	12	55	32.5
38 - 40	13	05	33.0
40 - 42	13	25	27.5
44 - 46	14	30	29.4
46 - 48	16	46	34.0
48 - 50	14	40	35.2

REFERENCES

1. Hillel, D., Soil and Water, Physical Principles and Processes, Academic Press, New York and London.

2. Hodder, R., Montana Agronomical Experimental Station, Personal communication with H. Roffman, WESD, October 8, 1973.

3. Missouri River Basin Comprehensive Framework Study, 6, Appendix, p 29-31.

2.6-2.10(10)-510310 MINING AND RECLAMATION PLAN

1. BACKFILLING AND GRADING

(a.) Backfilling and grading of the disturbed area will be completed prior to removal of reclamation equipment from the area.

(b.) Mining plan maps in Volume 2 show where the overburden and parting strata materials are to be placed in the backfill. Materials which are not conducive to revegetation techniques, establishment, and growth will not be left on the top or within eight (8) feet of the top of regraded spoils or at the surface of any other affected areas.

(c.) The exact location of solid waste disposal will be determined in cooperation with the Rosebud County Board of Health prior to obtaining an annual license. Locations will be consistant with the "Regulation Governing the Control and Licensing of Refuse Disposal Areas". In that they will be located so as to prevent the pollution or contamination of any waters within the state.(1) Disposal sites will be located a safe distance from any source of public or private water supply and will not be subject to flooding by surface water or high groundwater table, obstruct a natural drainage course, nor lead to surface or groundwater pollution by being located over a creviced limestone location or be in an area where springs exist. During 1974 there will be no fly ash generated or disposed of in any manner on the area to be mined by Western Energy Company.

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(1) Regulation 53.400, Regulation Governing the Control and Licensing of Refuse Disposal Areas. In: Status of Solid Waste Disposal in Montana, Report by the Solid Waste Section of Montana Department of Health and Environmental Sciences, Helena, Montana, December 31, 1972, pp 7-11.

(d.) Boxcut spoils will be out-cast from the area except where enough spoil room is not provided due to highways, railroads or future adjacent mining areas with 75 feet or less overburden. In such cases, boxcut spoils will be cast into the area to be mined and rehandled on a future pass as mining advances toward the center of the area. Final grading with dozers of the outside half of out-cast spoils will be concurrent with the mining at a 5:1 slope. Grading of in-cast spoils will be accomplished after rehandle, as the passes upon which they are placed are mined.

(e.) All final grading on the area of land affected will be to the approximate original contour of the lands within the area. The final surface of the restored area will not necessarily have the exact elevations of the original ground surface. With the exception of final highwalls, railroad loops and access road cuts and fills through unmined lands, no final graded slopes will be steeper than five horizontal to one vertical (5:1) unless otherwise approved in writing by the Department of State Lands.

(f.) Terraces, if required by recontouring plans, will be installed so as to be consistent with Department requirements.

(g.) Final grading with dozers and scrapers will be kept current with mining operations, except the outside slope of boxcut spoils next to a future adjacent pit.

All backfilling and grading will be completed within ninety (90) days weather permitting, after the Department of State Lands has determined that the operation is completed or that at prolonged suspension of work in the area will occur. Final pit reclamation will proceed as close behind the coal loading operation as the frequency and location of ramp roads, the use of overburden stripping equipment in highwall reclamation, and other factors may allow.

2. HIGHWALL REDUCTION

Highwall reduction, by Long Construction Company, will be as shown on the mining plan maps in Volume 2. Cross sections have been submitted to the Department prior to this permit application.

3. BUFFER ZONES

(a.) All mining activities will cease at least one hundred (100) feet from a property line, permanent structure, unmineable steep or precipitous terrain, or any area of unique scenic, historical, cultural, or other unique value.

(b.) The transition from undisturbed ground will be blended with cut or fill to provide a smooth transition in topography.

4. ROADS AND RAILROAD LOOPS

(a.) Haulage Way Road

Haulage way roads in general will not delay or prevent recontouring and revegetation on immediately adjacent spoils, although this may occur in some instances.

(b.) Ramp Roads

There will not be more than two (2) spoils side ramp roads/mile.

Ramp roads, beginning from the spoil edge of the pit being worked, will be engineered so as to exhibit an overall 7% grade, or steeper, until topping on graded spoils. As each cut pit is excavated, the ramp roads will be regraded as soon as practicably possible to remain at an overall 7% grade from the spoil side of the new cut.

(c.) Access Road

(i.) No sustained grade will exceed eight percent (8%).

(ii.) The maximum pitch grade will not exceed twelve percent (12%) for three hundred (300) feet.

(iii.) There will not be more than three hundred (300) feet of maximum pitch grade for each one thousand (1000) feet.

(iv.) The grade on switch back curves will be reduced to less than the approach grade and will not be greater than ten percent (10%).

(v.) Cut slopes will not be more than 2:1 in soils or 1/2:1 in rock.

(vi.) All grades referred to will be subject to a tolerance of two percent of measurement. Linear measurements will be subject to a tolerance of ten percent (10%) of measurement.

(d.) No off-site sedimentation will result as the result of construction along dry coulees or intermittent drainageways.

(e.) Drainage ditches will be constructed on both sides of the through-cut, and the inside shoulder of a cut-fill section, with ditch relief cross-drains being spaced according to grade. Water will be intercepted before reaching a switchback on large fill, and will be drained off or released below the fill. Drainage structures will be constructed in order to cross a stream channel, and will not affect the flow or sediment load of the stream.

(f.) All fill and cut slopes will be planted and/or seeded to provide a permanent vegetative cover the first planting and/or seeding season after construction of an access road, railroad loop or haulageway road outside of the area to be mined.

(g.) No roads or railroad loops will be surfaced with refuse coal, acid producing or toxic material or with any material which will produce a concentration of suspended solids in surface drainage.

(h.) All appropriate methods will be employed to prevent loss of haulage or access road surface material in the form of dust.

(i.) Upon abandonment of any road or railroad loop the area will be conditioned, seeded and adignate measures taken to prevent erosion. On completion of mining all roads will be closed and reclaimed unless the landowner requests in writing and the Department concur that certain roads or specified portions there of are to be left open for their use.

26-2.10(10)510320 BLASTING

1. Blasting will comply with all state and federal regulations regarding the blasting and handling of explosives.

2. These regulations will apply to overburden blasting as well as to other operations as the Department may determine.

3. A permanent sign will be erected near the entrances to the mining operation and will be plainly visible. The sign will be a minimum of four feet square with the words "Warning, Blasting Area" in letters not less than seven (7) inches in height upon a background of contrasting colors.

4. All blasting will be scheduled.

5. Blasting will not be conducted during hours of darkness, except in emergency situations such as those posed by approaching thunderstorms.

6. All holes primed will be blasted within seventy-two (72) hours.

7. Blasters will notify all adjacent residents within a one (1) mile radius in writing, by hand or by U.S. mail that blasting will occur at certain times of the day. Adequate measures will be taken to insure the safety on anyone near the blasting area prior to a blast.

8. All roads into the blast area will be guarded against unauthorized entry at least ten (10) minutes prior to the blast to insure that no one except those doing the blasting work are in the area. Suitable precautions for entry after a blast will be taken in the event of misfire or unusual circumstances.

9. Audible warning signals will be used.

10. All employees on the area of land affected will be notified of the blast signals. In addition, blast signals will be conspicuously posted at all entrances to the mine area.

11. Designated employees will be in charge of blasting operations, and they will supervise the fixing of all charges and all blasting operations.

12. One individual other than the blaster will be near the blast area, stationed at a safe distance, within view of the blaster and within contact of the blasters. He will be responsible for blast signals.

13. Blasters will take particular cognizance of any public or private facilities, active underground mines, liquid disposal wells, gas or oil wells, water wells, waterways, public or private water storage facility, or transmission lines in the blast area and will take appropriate steps to preclude damage to those facilities.

14. Certified blasters will keep a log describing each blast containing the following:

    a. The company name
    b. The location, date and time of blast;
    c. The type of material blasted;
    d. The type of explosive;
    e. The diameter of the blast holes;
    f. The number and depth of the holes;
    g. The description of the stemming;
    h. The shooting pattern of the blast, including information on maximum weight of charge per hole, per delay, and the burden spacing of the holes, and the type of initiation system.

15. Every effort will be made to minimize noise effects from blasting.

16. Every effort will be made to minimize the off-site damage occuring from the consussion or vibration effects of blasting.

17. Blasting will not be done in such a manner as to eject debris onto adjacent property outside the permit area or so as to constitute a hazard or endanger or damage persons or property.

26-2.10(10)-S10330 WATER QUALITY: IMPOUNDMENT, DRAINAGE AND TREATMENT

Western Energy will comply with the following requirements and with all applicable water quality standards established under Montana law and the rules adopted pursuant thereto:

(a) Non-degradation of waters. Waters within the public domain of the state will be maintained at their present high quality, consistent with the powers granted to the board. Such high quality waters will not be lowered in quality unless and until it is affirmatively demonstrated to the board, through public hearing, that such a change is justifiable as a result of necessary economic or social development and that the change will not adversely affect the present and future uses of such waters. In implementing this policy as it relates to interstate streams, Western Energy will supply the Administrator of the Environmental Protection Agency with such information as will enable the Administrator to discharge his responsibilities under the Federal Water Pollution Control Act.

(b) Impoundment and Treatment.

(i) Past experiences have indicated that impoundment and treatment will probably not be necessary. If, during mining operations, it becomes apparent that impoundment and treatment will be required:

(ii) Treatment facilities which may be required by the Department after commencement of the operation, if conditions arise that could not be anticipated at the time of the permit application, will be constructed with Departmental approval.

(iii) All treatment facilities will be maintained in proper working order by Western Energy and operated so that they will perform in the approved manner agreed upon by the Department and Western Energy at the time they are deemed necessary. All treatment facilities constructed and approved pursuant to the provisions of this rule shall be monitored by Western Energy to assure continuous satisfactory performance until approved reclamation has been accomplished.

(iv) Permanent water impoundments will not be allowed unless approved by the Department. If the Department determines at any time that a permanent impoundment area will not fill to expected levels, meet acceptable water quality standards or any other relevant criteria, the impoundment area will be regraded and surface drainage facilitated.

(v) No water quality treatment of approved lakes or ponds will be permitted without Department approval.

(vi) Monthly monitoring reports, where applicable, will be submitted to the Department, including the number of operating days, the gallons of drainage treated, a log of the tests made in accordance with Subsection (c) and a description of any operating problems and the corrective action taken.

(vii) The operator will, by the treatment of all runoff water, prevent the drainage into the waters of the state drainage from any source originating in the area affected under this permit, the pH of which is less than 6.0 or greater than 9.0, or which contains a concentration of iron in excess of seven (7) milligrams per liter (mg/l). The discharge must register positive net alkalinity (total alkalinity must exceed the total acidity) and the turbidity shall not exceed 100 Jackson Candle Units.

(viii) The maximum total allowable increase to naturally occuring stream turbidity is ten (10) Jackson Candle Units except that four (4) hours following a major precipitation event, the discharge will not contain suspended sediments in excess of five hundred (500) Jackson Candle Units above normal and not over one hundred (100) Jackson Candle Units above normal twenty-four (24) hours thereafter. All analyses will be defined and performed according to the Standard Methods for the Examination of Water and Wastewater, unless otherwise specified in writing by the Department. If the above standards in (vii) and (viii) are in conflict with Federal and/or other Montana state agencies the more stringent regulations will apply.

(c) Drainage

(i) All surface water which might damage regraded slopes or drain into the stripping pit will be intercepted on the uphill side of the highwall or other mine perimeters by diversion ditches and conveyed by stable channels or other means to natural or prepared watercourses outside the operation unless it is determined by the Department that such ditches and channels are unnecessary or would create a more serious pollution problem. Such conveyances will be of sufficient size and grade to prevent overflow into the mine area. If the ditches are likely to carry surface water only intermittently, they will be retopsoiled and revegetated with grasses, forbs and/or legumes. All constructed diversion ditches shall be included in the permit acreage and shown on the map.

(ii) Water accumulating in the course of the operation will meet the water quality specifications enumerated herein or shall be pumped or siphoned to a treatment or settling facility prior to discharge into a natural drainway. Under no circumstances will water be discharged onto highly erodable soil or spoil banks.

(iii) No deep mines exist in the affected area.

(iv) All drainage from the active mine area shall exit through impoundment or treatment facilities in accordance with Subsection (b)(i).

26-2.10 (10) - S10340 TOP SOILING

1. Top soil is defined as soil that contains naturally available nutrients and no toxic materials. The top 12" maintain natural nutrients and can support plant growth with low supplemental fertilizer. To establish a new grass cover on strip mined land, the top soils should be removed from the top 12" or less in most of this area and segregated from soils of lower depths. For reclamation, it is suggested that top soil be redistributed over the area with a layer approximately 4" in thickness. This method of reclamation has been proven successful in highway revegetation programs.

Another alternative for successful revegetation in Area A-1, E-1 and Pit #6 will be to remove all desirable soil up to 4' or 5' in depth. During reclamation, these materials can be redistributed and if very poor in nutrients they can be fertilized once or twice each year until the plants can maintain growth with minimum additional fertilizer. With proper species and proper seeding, there is every evidence that a satisfactory cover can be maintained. An example of such a case is land leveling for irrigation projects where as much as 30" of top soil is removed but high production is maintained with proper management and fertilizers. Land leveling is more severe because the top soil is completely removed, whereas in strip mining operations the removed topsoils are saved and replaced in the same area and the prospect of subsurface exposure is very small.

Both alternatives in this area should prove successful.

2. Locations of stockpiles are shown on the mining plan maps, Volume 2.

3. Reclamation Equipment

Pit 6 & Area E

2	Bulldozers
3	Wheel Tractor - Scrapers

Area A - Equipment has not been purchased but it will be similar to that used in Area E and Pit 6, assisted by the large dragline used in overburden removal as described on page 18 hereof.

26-2.10(10)-S10350

PLANTING AND REVEGETATION

1. Reclamation Research at Colstrip

The Colstrip land reclamation program in effect, is a long-term research program developed by WECo in association with the Montana Agriculture Experiment Station (MAES). Designed to continue through 1975, the program is currently one of the major research efforts for surface-mined reclamation in the western United States.(1) It is based on research begun in 1964 by the Montana Department of Highways and the Federal Highway Administration to test and evaluate revegetation techniques for highway roadsides disturbed by construction. Later, these research results were recognized to also apply to surface-mined lands in the coal fields of eastern Montana. Reclamation research projects sponsored by the state of Montana led to agreements in 1968 between the state and WECo to participate jointly in a program of reclamation research at Colstrip. The MAES staff at Colstrip also works closely with Montana's Departments of State Lands, Natural Resources, Highways, Health and Fish and Game. Federal agencies such as the U.S. Bureau of Mines, the Environmental Protection Agency and the Bureau of Land Management are also consulted actively.

Reclamation research efforts at Colstrip concentrate on the post-mining development of self-perpetuating and functional plant and animal communities and studies deal, therefore, with solving only problems critical to this type of restoration program. Intensive studies of overburden profiles, topsoiling and soil manipulation relative to erosion control and water preservation, fertilizers, seedling and transplant viability, and wildlife food and cover production are currently being conducted by MAES at the Rosebud mine (Pit #6). The results of this work should be directly applicable to the proposed mining area.

1.1 Overburden Profile Analysis

A chemical and physical analysis of the sedimentary layers comprising the overburden is important in evaluating the potential problems associated with subsequent reclamation. The soil layers most conducive to revegetation because of their low toxicity, suitable nutrient content, proper textural characteristics and acceptable resistance to weathering must be identified so that they can be placed nearest to the surface during backfilling.

Highwall stratigraphy at Pits 1, 3 and 6 was analyzed for percent moisture, texture, conductivity, pH, phosphorous and sulfur decomposition of specific layers.(2) Analysis of these data provide useful information on mineral content as a primary nutrient source for revegetation and spoil texture.

The mineral content of Colstrip spoils appears to be stratified. A general mineral deficiency was found near the surface and a mineral excess at intermediate levels. Extreme mineral excesses (mineral toxicity) were found only at depths closely associated with the Rosebud coal seam.(2) Vegetative productivity at any of these levels would normally be inhibited. While deficiencies in mineral nutrient are easily corrected by the proper use of fertilizers, the removal of toxic substances would be extremely difficult in eastern Montana where leaching effects are minimal.(2)

Spoil textural qualities have been analyzed with respect to differences affecting percolation, tilth, erosion and weathering. Several layers of clay found within the stratigraphic sequence would normally be detrimental to vegetative establishment, but the clay layers are thin and will be sufficiently diluted when mixed with other sandier spoils.(2) A shale layer located just above the coal seam is present in some areas and varies in thickness from six inches to several feet. Should this layer be left on top after backfilling, it would undoubtedly form an impenetrable mass and quickly seal the surface, leaving the area unsuitable for arable purposes.

1.2 Soil Manipulation Studies

In order to minimize erosion, promote soil stabilization and increase soil water retention, surface manipulation -- a mechanical modification of the surface of shaped spoils -- was found to be necessary. The results of earlier studies (1968-1970) indicated that striked (flat-topped) spoil ridges are inadequate for controlling slope runoff and surface exposure on newly backfilled study plots. Seed, fertilizer and soil were regularly washed from these smooth and compacted spoil banks before vegetation could become established. The loss of surface water also restricted vegetative establishment.

Recent studies at Colstrip (1970-1973) have resulted in the development of unique and effective procedures for retarding surface runoff and erosion, and at the same time increasing infiltration and storage of precipitation in mined areas. They include combinations of spoils design, topsoiling and surface manipulation by gouging, creating dozer basins or deep chiseling.(3) In an area such as Colstrip, where the annual precipitation averages about 14 inches, approximately 30% of which is snow, the conservation and full utilization of available water is a prime consideration.

a. Spoils Design

The predetermined design of spoil placement and slope is basic to any sound reclamation program. Any slope which is not mechanically stable cannot be permanently stabilized by surface treatment. Proper design also limits the direction and rate of surface runoff both within and outside the mining area and can eliminate stream pollution and siltation. Preplanning the shaping of spoils also minimizes earthmoving, resulting in lower costs, less soil compaction and reduced erosion potential.

b. Topsoiling

Topsoiling consists of removing the topsoil from land about to be mined and placing it on already mined areas which have been properly backfilled and shaped. When proper techniques are used, topsoiling aids the rapid establishment of stabilizing vegetation which minimizes erosion and surface water losses.

Studies on optimum depth of topsoil were conducted to determine the effect of topsoiling on vegetative establishment, productivity and erosion control.(3) Depth study plots were drill seeded with Cheyenne winter wheat and supplemented with relatively low amounts of fertilizer (40.5 lbs/acre of nitrogen and 19.5 lbs/acre of phosphorous). On non-topsoiled plots, heavy rains caused considerable erosion. On these topsoiled plots, results showed that no more than four inches of topsoil is necessary for successful plant establishment and maximum initial grain production (Table 17).

Topsoiling slope studies were conducted on four different slope gradients using an annual and perennial species of grass and a perennial shrub. Fertilizer was applied at rates similar to those used in topsoil depth studies. Analysis of canopy cover, frequency and productivity on the few slopes showed no significant differences by treatment. (Table 18 and 19). Vegetation stabilized on even the steepest slope (2.5:1) but this extreme gradient is not recommended because tilling and seeding with farm machinery were not possible.(3)

c. Surface Manipulation

Properly shaped, stable spoils with acceptable gradients are not the only prerequisites for establishing a vegetative cover. Spoils must also be capable of trapping and absorbing water.

Surface manipulation is a procedure designed to store precipitation, increase water infiltration, reduce saltation and limit wind erosion or weathering. By increasing the amount of roughened soil surface area, the number and variety of microniches for successful plant establishment are also increased. Roughened soil surface area may be increased by creating dozer basins on slope contours using a bulldozer blade dropped at an angle; deep chiseling using a modified Graham Hoeme plow with 12 chisels; or gouging using alternately dropped 25-inch diameter disc scoops. Each of these three treatments were studied on pre-shaped one-acre plots which were broadcast seeded with a mixture of grasses, forbs and shrubs (Table 20).

Results of these surface manipulation sutdies conducted during 1971-1972 indicated that any surface treatment improved the establishment of vegetation. There were no significant differences of plant density or plant survival estimates among the three surface manipulation treatments at the 90-percent level, but plant frequency was significantly greater on the gouged test plot (Table 21). Species which grew well on all treated plots are listed in Table 20. For nearly all these species which produce seed during the first growing season, including shrubs, growth was especially vigorous on gouged and dozer basin plots.

Soil moisture content was also improved by manipulating the surface of shaped spoils, but important considerations are the location of this water in the soil and its availability to vegetation. Soil moisture block conductance was measured at five depths to determine the water content as related to treatment. Increased conductance of the block indicates an increase in soil mositure content (Table 22). The gouged soil treatment stored significantly more soil moisture in the upper four feet of the soil profile than did the dozer or chiseled treatments (Tables 22). Because of this water availability, gouging greatly decreased the number of moisture stress days and consequently resulted in slightly increased seedling survival (Tables 21 and 23). Although both gouging and dozer basins were superior surface treatments to chiseling in terms of soil moisture and erosion control, chiseling always increases the growth and survival rate of seeded vegetation significantly. Since survival is limited, however, by soil moisture stress, chiseling would be a beneficial treatment in combination with either of the other two.

These types of surface manipulation clearly benefit reclamation operations in semi-arid areas such as Colstrip. The cost associated with any of the treatments or combination of treatments would be minor, while the benefits could mean the difference between reclamation success or failure(3).

3. Other Water Preservation Studies

Examples of other effective water preservation methods which greatly reduce or eliminate the need for irrigation at Colstrip are tubelings, double-root systems and condensation traps.

Tubelings are plants potted in narrow paper tubes approximately two feet long and two inches in diameter and encased in a half-inch plastic mesh sleeve. The narrow tube forces the roots of the plant to grow down and to develop a relatively narrow but deep root system to take advantage of deep soil moisture, to elimainate irrigation and extensive maintenance during the establishment period, and to reduce transplant shock and growth stagnation.(3,4)

The double-root system of planting involves connecting, via a horizontal joining root, pairs of native shrubs or trees with individual root systems. One plant in each pair is cut at the root crown, its root system is left deep in the coal spoils to transmit deep soil moisture through the connecting root to the other plant member which is planted in the dry surface soil.(3)

Condensation trap planting uses plastic sheeting to cover planting basins. The plastic sheeting traps soil moisture vapor which migrates to the surface of spoils. Plants are placed in spaced depressions in the spoils and covered with a plastic sheet which is sealed around the edges to trap air. The crown of the plant projects through a pre-cut hole in the plastic. Moisture condensing on the underside of the plastic irrigates the plants,(3) and the basin itself protects the seedlings from wind and sun until they are sufficiently mature. Being photosensitive, the plastic sheeting begins to disintegrate during the first growing season.

4. Fertilizer Studies

Previous soil analyses of raw spoils material at Colstrip indicated deficiencies in nitrogen and phosphorus, although potassium, is relatively abundant.(2)

In 1972, a fertilizer application rate study was conducted to determine the optimum rate of nitrogen and phosphorus applications for winter wheat grown on raw mine spoils at Colstrip.(3) Available nitrogen was tested at 0, 75 and 100 lbs/acre, and phosphorus was tested at 0, 50, 100 and 150 lbs/acre. The absence of either nitrogen or phosphorous had a negative vegetative response no matter what the concentration of the other nutrient. Each increase in either fertilizer rate showed a corresponding increase in plant production, but there was no significant difference between the two highest rates for either nitrogen or phosphorus (100 lbs/acre - 150 lbs.acre and 74 lbs/acre). The optimum rate of Colstrip raw spoil fertilization ofr winter wheat was 75 lbs/acre and 100 lbs/acre. When topsoiling is employed these rates may be reduced in accordance with the amount of available nutrients in the topsoil.

5. Seedling and Transplant Viability Studies

The primary concerns of the reclamation research program at Colstrip have been to find effective methods for establishing highly productive forage or grain vegetation and effectively insuring that native vegetation redevelops. To this end, extensive research has been conducted on determining the best species for achieving temporary stabilization, after which shrub and tree transplants and dryland pasture vegetation may become established.

Temporary stabilization with quickly germinating annual grasses and forbs is particularly desirable when perennial vegetation cannot be planted during spring or fall optimum seeding periods. Annual seedings are also important because they produce food and cover for avifauna and mammals, leave quantities of plant litter useful as surface mulch and contribute to the organic content of the soil in the form of root material.

Initial seeding of test plots in Spring 1972 resulted in good germination within 10 days and effective erosion control within three weeks.(3) In August, stabilizing species were analyzed for density, canopy cover and above-and below-ground vegetative production (Table 24). Similar tests will be conducted for plants such as common barley, wheat, oats and other species which require low nutrient levels and produce grain crops for small mammals.

Wildlife, abundant adjacent to and within the spoils at Colstrip,(3) is a continual threat to newly planted palatable vegetation. New plantings and seedlings attract mice, pocket gophers, rabbits and deer despite the mining activity, associated noise and general intrusion by man. Although their presence is highly desirable, the damage caused by these animals generally delays the establishing of vegetation. To counter this problem, caliper-size (1.5 inch diameter and 6-10 feet tall) bare-root stock trees, tall enough to exceed the reach of browsing deer, old enough to have lost their tenderness and succulence appeal and large enough to withstand rodent damage, were selected.

In Spring 1972, 10 trees of each species (silver poplar, plains cottonwood, laurel willow, golden willow, green ash, Russian olive and Chinese elm) were planted; half with and half without plastic aprons surrounding them. During the first summer, unusual precipitation patterns, and obvious damage from rodents and deer negatively affected the trees productive establishment. While all survived the first growing season, those with plastic aprons exhibited excellent growth and vigor. Subjective late-summer observiation ratings indicated good growth for the Russian olive, fair growth for the green ash laurel willow, green willow, Chinese elm and cotton wood, and poor growth for the silver poplar due to ground-level dieback. Sucker stems later developed form the base of the silver poplars, and one was allowed to grow as the main shoot of each. Full evaluation of experimental success must include winter survival and spring growth during future years.

In other transplant studies conducted during the spring and summer of 1972, root pads of rose and snowberry bushes and large ponderosa pine trees were excavated by bulldozer, transplanted in mine spoils and watered twice. Results indicated excellent potential for shrub and tree establishment providing special care is taken during relocation. Visual evaluation of vigor and average shoot length of shrubs was made in June. All rootpads of both shrub species survived, with the rose and four of seven snowberry plantings exhibiting vigor. The other three snowberry plants were in poor condition. Of the eight ponderosa pine transplants, two were in good condition, four were fair and two were poor. By fall, four of the eight had died. Refinements of these techniques may result in better transplant vigor and ultimate survival.

A long-range program was begun in 1970 to monitor the raw spoils establishment of dryland pasture vegetation, successional changes and stability over a period of serveral years. Off-set listering was used for soil surface manipulation the pasture seeding mixture including both native and introduced species known to be tolerant of dryland conditions (Table 25). Fertilizer was applied in the late fall of 1970 and again in January, 1972.

During the first two growing seasons excellent vegetative establishment was produced. Species production was determined near the end of the second growing season (Table 25). The total production of 1483.5 lbs/acre compares favorably with native range in the area which, in good condition, produces a maximum of 900 lbs/acre, not all of which is highly palatable.(3) In most recent experiments with similarly fertilized rangeland, native range did not produce much more plant material than did these raw spoils.(5)

Weed seeds (grasses and forbs) already present in the topsoil could have supressed the newly introduced mixed seed production. A proposition supported by the second phase (1972) of a Soils Media Study seems to substantiate this theory.

The dryland pasture seeding study indicates that a nutritious and highly productive forage crop can be produced on the raw spoil material of Colstrip. Although it is too early to judge the permanence of the established pasture, production during the 1973 growing season was better than previous years.(5)

6. Wildlife Food and Cover Production Study

Although reclamation plans for southeastern Montana call for restoring wildlife habitats and livestock grazing areas, little research has been directed specifically toward such restoration. The food and cover requirements of the region's vast array of wildlife would be impossible to artificially reproduce on restored land, but by providing a broad mixture of plant species, most being native to the region, the grass requirements of important wildlife species might be met. Reoccupation of the reclaimed lands will depend on the speed and success of restoration.

In Fall 1972, a game food area was developed at Colstrip to study food and cover relationships of a variety of palnt species to wildlife. Ten acres of spoils were shaped, and chiseled, and an additional six acres were gouged. These sixteen acres were seeded with either Cheyenne winter wheat and five shrub species including skunkbush, sumac, Russian olive, caragana, wild rose and willow, or broadcast seeded witha mixture of grasses, forbs and shrubs (Table 26). Study plots will be sampled periodically for wildlife utilization.

Table 17

EFFECT OF TOPSOIL DEPTH ON ABOVE GROUND WINTER WHEAT PRODUCTION AT WECo ROSEBUD MINE

Replicate Treatment	Above Ground Winter Wheat Production at Indicated Topsoil Depth, (g/m^2) Topsoil Depth (inches) 0	2	4	8
1	16.03	28.95	34.91	32.84
2	16.87	29.53	33.50	31.40
3	15.64	22.97	28.63	34.48
Mean	16.18*	27.15$^{\Phi}$	32.35†	32.91†

Mean values followed by the same symbol are not significantly different at the 95% level of significance.

Table 18

EFFECT OF SPOILS SLOPE GRADIENTS ON CANOPY COVER AND FREQUENCY OF VEGETATION AT WECo ROSEBUD MINE (3)

Plot	(Slope)	Sudangrass		Bromegrass		Saltbush		Bare Soil	
		Percent Canopy Cover	Percent Frequency	Percent Canopy Cover	Percent Frequency	Percent Canopy Cover	Percent Frequency	Percent Canopy Cover	Percent Frequency
A	(4:1)	38.8	100	6.2	67.5	0.6	27.5	54.4	25.0
C	(3:1)	51.6	97.1	6.5	94.1	0.5	20.6	41.4	26.5
B	(2-1/2:1)	45.3	100	4.2	77.5	0.5	30.0	50.0	17.5

Table 19

EFFECT OF SLOPE GRADIENTS ON MEAN PRODUCTIVITY AT WECo ROSEBUD MINE (3)

Plot	Slope	Mean Productivity, lb/Acre				
		Sudangrass	Bromegrass	Saltbush	Other	Total
A	4:1	689.6*	22.3*	10.7*	28.5*	751.1*
C	3:1	865.3*	21.4*	4.5†	16.1*	907.3*
B	2.5:1	812,7*	18.7*	5.4†	33.9*	870.7*

Means in columns followed by the same symbol are not statistically different at the 95% level of significance.

Table 20

SEEDING MIXTURE BROADCAST SEEDED ON SURFACE MANIPULATION TREATMENT PLOTS AT WECo ROSEBUE MINE (3)

	Common Name	Scientific Name
†	Crested wheatgrass	Agropyron cristatum
†*	Thickspike wheatgrass	Agropyron dasystachyum
†	Tall wheatgrass	Agropyron elongatum
	Siberian wheatgrass	Agropyron sibericum
*	Western wheatgrass	Agropyron smithii
*	Slender wheatgrass	Agropyron trachycaulum
*	Big sagebrush	Artemisia tridentata
†*	Cicer milkvetch	Astragalus cicer
†*	Fourwing saltbush	Atriplex canescens
	Field brome	Bromus arvensis
	Lincoln brome	Bromus inermis
*	Buffalograss	Buchloe dactyloides
*	Prairie sandreed grass	Calamovilfa longifolia
*	Rubber rabbitbrush	Chrysothamnus nauseousus
	Barnyard grass	Echinochloa crusgalli
*	Winterfat	Eurotia lanata
	Tall fescue	Festuca arundinacea
	Yellow sweetclover	Melilotus officinalis
	Sainfoin	Onobrychis vicialfolia
*	Indian ricegrass	Oryzopsis hymenoides
*	White prairieclover	Petalostemon oligophyllus
*	Nuttall alkaligrass	Puccinellia airoides
†*	Greasewood	Sarcobatus vermiculatus
*	Alkali sacaton	Sporobolus airoides
*	Green needlegrass	Stipa virdual

† Plants which grew well on all treatment plots.
* Species native to Montana.

Table 21

EFFECT OF SURFACE MANIPULATION ON PLANT DENSITY, SURVIVAL AND FREQUENCY AT WECo ROSEBUD MINE (3)

	CHISELED	GOUGED	DOZER BASIN
Density (6/20/72), plants/m^2			
Grasses	139.0	107.2	172.8
Legumes	9.6	22.4	32.0
Shrubs	1.6	4.8	3.2
Total	150.2*	134.4*	208.0*
Density (8/8/72), plants/m^2			
Grasses	180.8	97.6	418.8
Legumes	9.6	19.2	25.6
Shrubs	4.8	6.4	4.8
Total	123.2*	123.2*	179.2*
Survival for period, %	82.0	91.7	86.2
Frequency (6/20/72), %			
Grasses	70.0	80.0	74.7
Legumes	13.3	33.3	34.7
Shrubs	7.3	10.0	3.3

* Figures are not significantly different at the 90% level of significance.

Table 22

EFFECT OF SURFACE MANIPULATION TREATMENT ON SOIL MOISUTRE BLOCK CONDUCTIVITY AT WECo ROSEBUD MINE (3)

Topsoiled Spoils Treatment	Average Soil Moisture Block Conductance at Indicated Depth, μα					
	Soil Depth Tested **					
	2 in	1 ft	2 ft	3 ft	4 ft	Mean
Dozer	45.5*	50.3*	58.8*	74.6*	86.4*	63.12*
Chisel	42.6*	42.5†	61.7*	73.2*	90.6*	62.12*
Gouge	48.0†	57.4Φ	79.1†	93.2†	115.7†	78.68†

Figures in each column followed by the same symbol are not significantly different at the 95% level of significance.

**Block conductivity tests were made during the period 5/12/72 to 11/2/73.

Table 23

EFFECT OF SOIL SURFACE TREATMENT ON PLANT WILTING(3)

Treatment	Period Soil Moisture Dropped Below The Wilting Point* for Plants, Days				
	Soil Depth Tested				
	Surface	1 ft	2 ft	3 ft	4 ft
Chisel	48	71	51	20	0
Dozer	47	19	46	0	0
Gouge	46	6	0	0	0

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*The wilting point is that level of soil moisture at which water becomes unavailable to plants and permanent wilting ensues. The general wilting point for plants in the Colstrip area is considered to be approximately 15 atmospheres.

Table 24

PLANT DENSITY, CANOPY COVER, ABOVE-GROUND PRODUCTION AND ROOT PRODUCTION OF TEMPORARY STABILIZING SPECIES AT WECo ROSEBUD MINE(3)

	Sorghum	Sudangrass	Millet	Rye	Rape
Density (plants/m^2)	490	332	406	464	341
Cover (percent)	37	24	49	27	41
Above-ground Production (lbs/Acre	966	452	759	443	720
Root Production in Upper 45 cm (lbs/Acre	3614	971	1318	4062	448

Table 25

PRODUCTION BY SPECIES FOR THE DRYLAND PASTURE SEEDING MIXTURES STUDY AT WECo ROSEBUD MINE(3)

Common Name	Production (lbs/Acre)	
Perennial grasses		
Orchard grass	736	
*†Wheatgrass	266	
Smooth bromegrass	138	
*Indian ricegrass	34	
Hard fescue	(trace)	
*Green needlegrass	(trace)	
TOTAL	1,174	1,174
Legumes		
Alfalfa	171	
Cicer milkvetch	26	
*White prairie clover	(trace)	
TOTAL	197	197
Shrubs		
*Fourwing saltbush	0.5	
*Winterfat	(trace)	
TOTAL	0.5	0.5
TOTAL Annual Grasses	36	36
TOTAL Forbs (Weeds)	76	76
TOTAL PRODUCTION		1,483.5 lbs/Acre

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*Indicates species native to Montana

†Wheatgrasses include: thickspike, tall, crested, western, Siberian, and slender wheatgrass.

Table 26

WILDLIFE FOOD AND COVER SEED MIXTURES FOR AREA AROUND GRAINFIELD SITE AT WECo ROSEBUD MINE(3)

Mixture 1 (seeded Oct. 19, 1972)	Mixture 2 (seeded Nov. 1, 1972)	Mixture 3 (seeded Nov. 1, 1972)
Smooth bromegrass	Sainfoin	Thornapple
Tall wheatgrass	*Fourwing saltbush	Russian olive
*Indian ricegrass	*Rubber rabbitbrush	*Ponderosa pine
Ranger alfalfa	Three-leaf sumac	
Cicer milkvetch	Caragana	
*Greasewood		

*Indicates species native to Montana.

2. THE RECLAMATION PROGRAM AT COLSTRIP

WECo believes that Montana's surface-mined lands can become a productive and lasting asset to the state if sound and viable coal mine reclamation techniques are used. In association with MAES, WECo sanctioned and funded the first large-scale effort to investigate reclamation problems in Montana and to devise a development plan for re-creating a productive post-mining environment. Since operations at Colstrip began in 1968, surface-mined land up to three ridges behind mining operations has been in active stages of reclamation. WECo's program for future reclamation is preplanned and research documented. Reclamation at Colstrip is not merely an attempt to disguise the effects of surface mining; rather, it represents ecological rejuvenation as an integral part of the mining process.

2.1 Preplanning

The joint research efforts of WECO and MAES represent only some of the more meaningful contributions toward the difficult talk of dryland reclamation. Many more experiments are in progress and several promise favorable results. Both proven reclamation techniques and techniques under development are being and will continue to be used by WECo. Each of the major reclamation approaches described earlier--spoils segregation, contour restoration, surface manipulation, topsoiling and appropriate seeding to hasten habitat development and provide community stability--are planned to be used on areas scheduled for reclamation.

a. Spoils Segregation

Prior to overburden removal, overburden profiles will be analyzed, and procedures drafted to insure proper replacement of spoil materials and separation of those spoil layers identified as undesirable for vegetative establishment. The dense clay layer located just above the coal seam will be placed at the foot of the spoils pile and replaced during backfilling so that it will not interfere with the flow of the Rosebud aquifers or remain within eight feet of the resulting surface. Other thinner clay layers will naturally mix with productive spoil layers during removal and replacement of the overburden. The stripper-operator will identify harmful spoil layers by color and textural differences as well as stratigraphic location and will separate them from other overburden materials so that only negligible amounts of coal, coal stack, clay and other objectionable material will be left exposed on the surface.

b. Spoils Shaping, Land Contours and Surface Drainage

Montana requires that strip-mined lands be restored to their original contours. While exact elevations cannot be restored because of the 25 foot net loss corresponding to the coal seam, similar contours, land forms and major drainage patterns can be maintained.

Removal and subsequent replacement of a give layer of overburden usually results in an increase in the depth of the overburden. At Colstrip, this increase, or swell-factor, is approximately 25 percent. The effect of this swell-factor combined with coal removal for an overburden thicknesses of zero to 150 feet are shown in Table 27. After restoration, the net change in elevation over the mined area will be a decrease of 6.25 feet. The overburden will then settle slowly.

During reclamation the overburden will be shaped and regraded to restore land contours. The interface between nonmined and and mined areas will receive particular attention to avoid sharp escarpments or raw faces subject to erosion and weathering. Highwalls will be sloped or graded to 3:1.

Mining activities near Armells Creek will also be carefully regulated since any significant change in the soil characteristics of either the stream bed or drainage slopes can result in erosion and siltation.

Much

of the land along Armells Creek between Areas A and B and in the eastern part of Area C has already been designated non-mining. Since the central and western portions of Area C contributes to the initial drainage for the creek, a strip at least 50 feet wide will be left on both sides of the creek. Areas beyond this limit with less than a 25-foot overburden will also be left unmined, in order to eliminate the possibility of adverse drainage effects caused by a negative net change in ground level (Table 27).

c. Surface Manipulation

Surface manipulation is indispensable for reclamation. Gouging is the currently preferred method of surface manipulation because it consistently provides the best soil-water availability to newly seeded areas. It will be supplemented by chiseling in areas requiring additional manipulation. Off-set listering, a technique currently being researched, also seems to give very satisfactory results and will be used extensively if it should prove superior to gouging.

d. Topsoil Removal, Storage and Replacement

Topsoil removed prior to mining will be transported directly to previously mined areas which have been shaped and graded or stockpiled for later use, Optimum topsoil depth will be determined by the area's slope and the types of surface treatment and revegetation seeding to be used. No topsoil is presently expected to need long-term storage which would require compaction or stabilization.

Areas with little or no original topsoil profile will need additional topsoil. In addition, silt collected in the plant water intake basin in the Yellowstone River will be transported to the reclamation area and mixed with the highest overburden strata to give soil of desired quality and texture. Montana Power Company's J. E. Corette plant in Billings has successfully used river silt of this type to establish vegetation.

e. Establishment of Vegetation

Revegetation at Colstrip will include a broad selection of mixed species, both introduced and native, with a variety of functional values and life forms which are to respond well to restrictive dryland conditions (Table 28).

Seed mixes will include quickly germinating annual grass or grain species (millet, sorghum, sudangrass, rye and rape) for temporary surface stabilization and hardy perennial grasses (wheatgrasses, orchard grass, prairie sandreen grass and Indian ricegrass), nitrogen-fixing legumes (cicer milkvetch, alfalfa and colvers) and other forbs (sagewort, sainfoin and cicer milkvetch) for permanent stabilization. Seeding mixtures will be drill or broadcast seeded over the prepared surface, at a rate determined by desired optimum plant density, type of soil surface preparation, fertilizer applications and seeding dates.

A variety of shrubs and trees will also be seeded and transplanted. Shrubs have been selected for their ability to form extensive root systems and make the most efficient use of available soil moisture (Table 28). Tree species have been selected which naturally adapt to the climate and soil conditions at Colstrip; they will be planted in areas such as drainage confluences where water is abundant. Species such as Russian olive and some willows will be introduced to maximize the use of available water. Special care will be taken in the excavation, transportation, planting and past-planting operations when locally grown trees and shrubs are transplanted.

2. Green-Strip Preservation

In portions of each mining area, mining is presently unecomonical because the overburden is greater than 150 feet. Designated as "green-strips", these areas support developed stands of ponderosa pine and native range grasses, forbs and shrubs. Consistent with good practices, these green-strips will be preserved wherever possible.

WECo plans to preserve green-strip areas as ecological buffer zones to help maintain Colstrip's natural biotic community. They will:

- help maintain the natural state of the land
- serve as a reseeding source for ponderosa pine and other naturally occurring vegetation.
- offer suitable refuge for wildlife during mining and act as an immigration habitat afterward.

Green-strip areas will also be saved from secondary disturbances related to surface-mining activities. Exact boundaries will be marked and machinery will not be allowed to enter these areas. When occasional exploratory core drillings have to be made, specific entry and departure routes will be established to ensure minimal disturbance. Within each mining section the green-strips will be protected from the intrusion of surface mining and related activities until vegetative and faunal development in the reclaimed mined areas has become established.

3. Future Land Use

The Colstrip area will be restored to a mixed-prairie grassland, interspersed with ponderosa pine. Reclaimed land will be used primarily by range wildlife and livestock. The selected vegetation is intended to meet the food and cover requirements of area wildlife while providing improved forage type and productivity for livestock.

4. Schedule

In accordance with Montana law, reclamation will follow the stripping operation, by two cuts, providing continuous grading and contouring of the spoil bank and immediate replacement of topsoil. Once reclamation has begun, there will be a continuous integrated process of stripping topsoil, hauling and spreading; blasting overburden and stripping; contouring spoil; and reseeding.

5. Reclamation Costs

Reclamation costs are difficult to estimate because there is no data on a large-scale operation in similar terrain available for analysis.

To date, the Colstrip program has essentially been one of research. The 10 acre demonstration plot, worked jointly by WECo and MAES, provides the most meaningful estimates of costs, though these may be inflated due to the limited nature of the project.

In operating this demonstration plot, the major expense was the initial treatment which consisted of shaping and gouging the spoil banks at an average per acre cost of approximately $300 (representing mainly dozer work).

Hauling topsoil represented and additional $150 per acre. This expense will be greater if topsoil has to be stockpiled before being used, and it should be substantially higher on the site due to longer hauling distances and increased stripping costs.

Costs for seed at a rate of 160 pounds per acre (100 pounds of temporary stabilization species, 60 pounds of perennial grasses and legumes), totaled approximately $35.

Seventy deciduous trees were planted at an average per acre cost of $20 shrubs were planted at about $12 per acre, and fertilizers applied to date totaled about $12 per acre.

Labor costs incurred at the demonstration plot are not as easily identified as other costs. While MAES staff wages totaled approximately $142 per acre, this figure may reflect the higher costs of reclaiming a small land area as well as the higher salary scales of professionals. An ongoing program covering larger areas should require a substantially lower outlay.

Miscellaneous expenses including transportation, overhead, hardware and other materials are also difficult to estimate. The best estimate to date is $90 per acre.

The cost per acre for operating the ten-acre demonstration plot and projected cost per acre for a large-scale operation are summarized below:

	Demonstration (1971)	Probable Large-Scale (1973)
Highwall Reduction		$ 80
Topsoil replacement	$150	250
Shaping and gouging	300	350
Seed	35	45
Trees	20	25
Shrubs	12	15
Fertilizer	12	15
Labor	142	140
Miscellaneous & Overhead	70	90
TOTAL - PER ACRE	$741	$1000

Although per acre costs may vary widely depending on location, this list represents an average expense which may be used to estimate reclamation costs.

Table 27

CHANGE IN GROUND LEVEL DUE TO OVERBURDEN SWELLING

Overburden Depth (feet)		
Stripping	After Stripping (25% swell factor)	Net Change In Ground Level*
0	0.0	-25.0
50	62.5	-12.5
100	125.0	0.0
150	187.5	+12.5

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* Assuming removal of 25-foot coal seam.

Table 28

PLANT SPECIES TO BE USED DURING RECLAMATION AT WECo ROSEBUD MINE

Common Name	Scientific Name
Grasses	
† Fairway crested wheatgrass	*Agropyron cristatum*
†*Thickspike wheatgrass	*Agropyron dasystachyum*
† Tall wheatgrass	*Agropyron elongatum*
Siberian wheatgrass	*Agropyron sibericum*
*Western wheatgrass	*Agropyron smithii*
†*Slender wheatgrass	*Agropyron trachycaulum*
† Pubescent wheatgrass	*Agropyron trichophorum*
† Dwarf rape	*Brassica campestris*
Field bromegrass	*Bromus arvensis*
† Lincoln bromegrass	*Bromus inermis*
*Buffalograss	*Buchloe dactyloides*
*Prairie sandreed grass	*Calamovilfa longifolia*
Barnyard grass	*Echinochloa crusgalli*
† Annual rye	*Lolium sp.*
†*Indian ricegrass	*Oryzopsis hymenoides*
† Millet	*Panicum sp.*
*Nuttall alkaligrass	*Puccinellia airoides*
† Sudan grass	*Sorghum sudanense*
† Common sorghum	*Sorghum vulgare*
*Alkali sacaton	*Sporobolus airoides*
*Green needlegrass	*Stipa virdual*
Forbs	
† Cudweed sagewort	*Artemisia ludoviciana*
†*Cicer milkvetch	*Astragalus cicer*
Alfalfa	*Medicago sativa*
† Yellow sweet clover	*Melilotus officinalis*
Sainfoin	*Onobrychis vicialfolia*
*White prairie clover	*Petalostemon oligophyllus*

Table 28 (continued)

Common Name	Scientific Name
Shrubs	
*Big sagebrush	Artemisia tridentata
†*Fourwing saltbush	Atriplex canescens
Caragana	Caragana sp.
*Rubber rabbitbrush	Chrysothamnus nauseousus
*Winterfat	Eurotia lanata
† Sea buckthorn	Hippophae rhamnoides
† Honesuckle	Lonicera tatarica
† Sandcherry	Prunus besseyi
† Currant	Ribes sp.
† Skunkbush sumac	Rhus trilobata
† Wild rose	Rosa woodsii
†*Greasewood	Sarcobatus vermiculatus
† Buffalo berry	Shepherdia argentia
† Snowberry	Symphoricarpos albus
Western snowberry	Symphoriscarpos occidentalis
† Yucca	Yucca glauca
Trees	
† Russian olive	Eleagnus angustifolia
† Green ash	Fraxinus pennsylvanica
† Rocky mountain juniper	Juniperus scopulorum
*Ponderosa Pine	Pinus ponderosa
† Cottonwood	Populus deltoides
† American plum	Prunus americana
† Golden willow	Salix alba vitellina
† Laurel willow	Salix pentandra
† Purple willow	Salix purpurea
† Siberian elm	Ulmus pumila

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* Species which are native to Montana

† Plants which grew well during research studies.

PART 2

ENVIRONMENTAL IMPACT ANALYSIS

PART 2

ENVIRONMENTAL IMPACT ANALYSIS

1. INTRODUCTION

Presently, the electric utility industry requires about 25 percent of all the basic energy sources used in the United States. Coal, gas, oil and nuclear fuels. Based on future energy projections, by 1985 the utility industry will be using about 35 percent and by the year 2000 nearly 50 percent of all basic fuels used in the United States. This requirement will more than double our present generating capacity. In the next quarter century we expect to develop extensive gains in such alternate energy technologies as geothermal, fusion and solar energy. While this time consuming development is going on, however, it is necessary for the utility industry to rely upon sources of energy in which we presently have demonstrated technical competence and of which we have dependable current quantities.

In the United States we have sufficient domestic coal reserves to supply all our energy requirements for several hundred years, at our present rate of consumption. At an accelerated consumption rate this time will be shortened, obviously-and it is for this reason that the utility industry is vitally interested in supporting the research necessary to develop exotic energy sources into viable systems for our future needs. However, today, in the interim period, we are faced with a growing demand for energy, and at the same time we are restricted in our ability to produce it by increasingly more stringent anti-pollution controls.

The National Environmental Protection Act of 1969 created increased demand for non-polluting fuels such as low-sulfur coal, low-sulfur oil and natural gas. Nationally, these low-sulfur fuels are in limited supply. However, the northern Great Plains states, Montana, Wyoming, Nebraska and the Dakotas, have a vast quantity of low-sulfur coal that represents 40 percent of all American coal reserves. Colstrip lies approximately at the northwest corner of this vast reserve area called the Fort Union Coal Basin.

These deposits of low-sulfur coal permit the reliability of sulfur removal equipment, if required, to be high. The low-sulfur content also reduces the amount of alkaline chemical additive needed in the removal process and minimizes the problem of waste product disposal. Because of the relatively high amounts of calcium and magnesium oxides in the ash from Colstrip coal, the retention of some of the original sulfur in the ash from utility boilers will reduce the amount of sulfur oxides emitted. Additionally, the low sodium oxide content reduces the possibility of excessive slagging, with its detrimental impact on boiler operation. Furthermore, the consistently favorable overall stripping ratio of Colstrip coal will minimize cost increases on long-term sales. These factors, together with the establishment of unit train rates for coal shipments, have made Colstrip coal economically attractive and readily accessible to eastern markets.

Since 1968, before Western Energy first began large scale operations of the Rosebud Mine in Colstrip, Montana, Western Energy Company contracted with and has vigorously supported efforts of the Montana Agricultural Experiment Station to research and determine the best reclamation practices to follow in the Colstrip area. The specific goals of Western Energy in this program are to reclaim the older spoils areas and to use progressive mining methods which will allow the safe removal of nationally needed low-sulfur coal, and at the same time expedite the restoration of newly mined areas with as little disturbance to the local ecology as possible. In many cases, it has been found through experimentation, proper restoration will improve the moisture retention characteristics of the terrain to result in hardier stands of vegetation. As in the past, future operations of Western Energy Company will be in compliance with existing state and Federal environmental, health and safety regulations.

Because of the increasing national need for low-sulfur coal as a primary energy source and the particular advantages associated with the Colstrip resource, together with Western Energy's excellent record in reclamation research and field experience, we believe that mining the Western Energy coal holdings in Rosebud County is necessary and practical from both the economic point of view and as a valid land ethic.

The area surrounding Colstrip, is representative of the southeastern region of Montana in both floral and faunal composition. The mixed grasslands pine woodlands exhibit an ecological similarity throughout an area of relatively uniform climate and parent soil material. A portion of the grasslands around Colstrip has been converted to agricultural use. These agronomic areas comprise planted and fallow fields with an emphasis on grain and hay crops. With the exception of cattle replacing the buffalo, animal life in the area is relatively unchanged from former times.

A detailed archeological survey, contracted for by Western Energy Company and performed by the University of Montana in 1971 and additional work in 1973 by the Montana College of Mineral Science and Technology found a number of archeological sites which provided information on the life of its Plains Indians in the Colstrip area. These sites included examples of Indian rock art, rock shelters and lookout sites, as well as one bison hill location. One occupation site was located Area A-1, but it does not fall into the area to be mined in 1974. Should future operations indicate that this site will be disturbed and if a more detailed investigation is deemed necessary at that time, Western Energy will assume responsibility for excavations by professionals as far in advance of the disturbance as possible.

There are no significant or unique geological formations in the area for which the 1974 strip mining permit has been applied. Some sedimentary (sandstone) bluffs are in the area to be mined. Since this type of formation abounds throughout this part of Montana, they could not be considered unique scenic formations.

2. CHARACTERISTICS OF ROSEBUD COAL

Coal began to form some 250 million years ago during the Carboniferous Period in humid tropical rain forests. Fallen trees and ferns piled layer upon layer, rotted and formed peat. After parts of the earth sank, streams and oceans came in and deposited sand and silt over them. Where this phenomenon occurred, various intensities of heat and pressure created the world's classes of coal. These are: brown coal, lignite, anthracite, bituminous and subbituminous.

Tertiary Age coal, the type most abundant in Montana, is black and generally grades downward from lignite to subbituminous from east to west across the Fort Union region in Montana.

Most of the subbituminous deposits in the U.S. are located in Wyoming, Colorado, Montana, Washington and Utah. In Montana, most of the subbituminous coal beds are located in the Eastern province in the Fort Union Formation.

From an examination of the characteristics of the coal from Areas A, Pit 6 and E (Laboratory sheets, Appendix D, and Table 31) it is apparent that the composition of the coal is relatively homogeneous across the field. Sulfur content is low, approximately 0.75%, making this coal well suited for burning since its combustion produces relatively little sulfur dioxide.

As found in all coal, a variety of other impurities are contained in this coal as listed in Table 32 as well as some natural radioactivity as shown in Table 33.

Fluoride content of the Rosebud seam was evaluated by the Montana State Department of Health and Environmental Sciences. The results of three commercial laboratories plus some of the state's own analysis were reviewed, Table 34. Because of the widespread of results obtained by one laboratory, their results were not considered valid.

Mercury content of the Rosebud seam coal was analyzed by four independent laboratories. The average results obtained varied rather widely (Table 35). The Montana State Department of Health and Environmental Science has questioned the results of a low value obtained by one laboratory (the same laboratory who reported a large spread of data in their fluoride analysis). However, an even lower number for mercury was reported by a Bureau of Mines sponsored analysis conducted in 1971.(1) In view of all the foregoing results, it is reasonable to consider that the mercury content of the Rosebud seam coal to be approximately 0.15 ppm. Laboratory data for coal samples from Areas A-1 and E are in Appendix D.

REFERENCES

1. Schlesinger, M.D., and Schultz, H., "An Evaluation of Methods for Detecting Mercury in some U.S. Coals", Report of Investigation No. 7609, U.S. Bureau of Mines, 1972.

TABLE 31

CHARACTERISTICS OF ROSEBUD SEAM COAL IN THE COLSTRIP AREA

Area	No. Samples	Average Value, %					Avg. Heating Value, Btu/lb
		Moisture	Ash	Volatiles	Fixed Carbon	Sulfur	
A	4	20.99	10.75	29.65	38.48	0.77	9067
E	12	21.25	8.67	31.24	38.63	0.74	8800
Pit 6	59	24.30	8.59	28.60	38.97	0.75	8842

TABLE 32

IMPURITIES IN COLSTRIP COAL

(Pit 6)

Element	Average Impurity Content, ppm
Aluminum	7400
Arsenic	Trace
Beryllium	Trace
Boron	Trace
Bromine	21.0
Cadmium	0.23
Chlorine	165.0
Chromium	2.9
Cobalt	0.44
Copper	<100.0
Europium	0.080
Fluorine	See Table 34
Hafnium	0.79
Iron	1350.0
Lanthanum	3.9
Lead	4.81
Maganese	95.0
Magnesium	2000.0
Mercury	See Table 35
Samarium	0.53
Scandium	1.0
Selenium	0.016
Sodium	145.0
Tantalum	0.25
Terbium	0.061
Thallium	1.4
Titanium	380.0
Vanadium	5.5

TABLE 33

NATURAL RADIOACTIVITY IN COLSTRIP COAL

(Pit 6)

Element	Radioactivity Level
Radium - 266	2.8 pCi/g
Thorium - 232	3.0 µCi/g
Uranium	0.7 µCi/g

TABLE 34

FLUORIDE CONCENTRATIONS IN COLSTRIP COAL AS DETERMINED BY FOUR LABORATORIES

Laboratory	No. of Samples	Minimum	Maximum	Mean
Truesdail Laboratories	16	11.0	38.0	24.8
Western Applied Research	17	33.0	42.0	37.4
Radian Corporation	17	25.1	48.3	34.3
State of Montana	7	20.0	43.5	29.8

TABLE 35

MERCURY CONTENT IN COLSTRIP COALS

Data Source	Sample Source	No. of Samples	Avg. Mercury Content, ppm
Truesdail Laboratories	Areas A and B	8	0.14
Study sponsored by U.S. Bureau of Mines	Rosebud County	-	0.061
Montana State University	Pit 6	33	0.21
W Research & Development Center	Coal Pile, J.E. Corette Plant	1	0.11
Average			~ 0.15

3. MINING AND RECLAMATION DESCRIPTION

Mining operations which currently are being conducted in the Pit 6 area will be continued into Area E. The mining practices followed by Western Energy Company and Long Constraction Company, WECo's mining contractor, are in compliance with the laws and regulations governing strip mining operations in the State of Montana. Strip mining operations which will be covered by this permit application by Western Energy Company will continue to reflect good mining and reclamation practices. Since the specific mining operations incident to this permit have been discussed and shown in detail on the mining maps, Volume 2, the general mining and reclamation description that follows briefly summarizes the overall operations anticipated for 1974.

Topsoil will be removed from areas to be mined and stockpiled for use during reclamation. Based on tests made prior to mining, the overburden will be removed and so placed as to permit reclamation with the most judicious mixing or placement during reclamation; i.e., overburden layers with chemical contents that approach toxic levels will be replaced neither near the restored aquifier nor closer than 8 feet to the regraded surface. Blasting, to break up both overburden and the Rosebud coal seam for expedient removal, will be accomplished in accordance with the governing regulations and in such a manner as to minimize the localized noise, shock and dust. Haulage roads will be maintained in such a manner that dust will be minimized.

Laboratory analysis of the soils in the areas to be mined indicate that no excessive toxicity existed and that minimum soil additives will be required to ensure proper germination and growth on reclaimed areas.

Entrapped runoff water, during mining operations, for the main part will be used for irrigation of reclaimed and reseeded areas. However, this water will be tested prior to either being used for irrigation purposes or being drained off. Excess water will be treated, if warranted, before being allowed into Armells Creek on Cow Creek.

Section S10350 of the Mining Permit Application details the essentials of the revegetation program which will be followed.

4. LOCAL CLIMATOLOGICAL CHARACTER

Most of the meterological data used to characterize the Colstrip site were obtained from a study performed by Montana State University.(1) Measurements of wind speeds and directions, temperature and relative humidity were taken at Colstrip from November 12, 1971 through November 11, 1972. Most wind data were collected with equipment located at the top of a 307-foot tower; supplemental data were obtained from pilot balloon observations. Temperature gradients were obtained using thermocouples located at 59 and 294 foot levels on the tower.

Data on the height of ground-based inversions and maximum mixing depths were obtained from aircraft soundings taken above Colstrip area. Long-term climatological data characterizing climatic conditions in this area of southeastern Montana were obtained from three first order National Oceanic and Atmospheric Administration (NOAA) stations surrounding the Colstrip area: Billings,(2,3) Miles City (3,4) and Sheridan.(5,6) The Colstrip site is approximately 52 miles southwest from Miles City, 88 miles east southeast from Billings and 77 miles north northeast from Sheridan.

Southeastern Montana is in the mid latitudes which have a prevailing westerly airflow. The weather in the region of the Colstrip site is typical of a continental climate; it is characterized by abundant sunshine, low relative humidity, light rainfall confined largely to the warmer half of the year, moderate wind movement, large diurnal temperature changes and pronounced temperature extremes (Table 36).

Winters are quite cold with inversions of cold Artic air from the north being occasionally interrupted by storms from the Pacific Ocean. Cold waves accompanied by temperatures of zero or below last from two to four days. Zero and sub-zero temperatures occur on the average for 170 days, mostly during November, January, February, March and April. Temperatures above 90°F occur on average for 30 days during June, July, August and September.

U. S. Weather Bureau data for Billings, Miles City and Sheridan Airports show maximum record temperatures of 105°F, 110°F and 106°F, respectively; minimum record temperatures were -26°F, -37°F and -30°F. The annual average daily maximum ranges between 58.5°F and 58.9°F for the three stations and the minimum ranges from 31.5°F to 36.2°F. Annual averages are 47.5°F, 45.8°F and 45.2°F, respectively. The one year data for Colstrip reveal that the annual average daily maximum and minimum temperatures are 51°F and 38°F, respectively, with an annual average of 45°F; these are similar to the temperatures for the three other weather stations. Monthly climatological temperature data for the three stations and Colstrip are given in Table 37.

Total precipitation averages about 14 inches per year,Table 37. The heaviest rains -- mostly in May and June -- are caused by storms involving moisture from the Gulf of Mexico. The combination of this early precipitation in the growing season precipitation with rapidly rising temperatures in May and June, followed by hot, dry summers, has helped to produce a stable agricultural base in southeastern Montana. The wettest recorded month for Billings, Miles City and Sheridan was June 1944 with a total of 7.64, 9.78 and 9.54 inches of rain. The most rain in a 24-hour period in these stations was 2.83 (May), 2.71 (June) and 3.44 (June) inches, respectively. The average annual rainfall is 13.23, 12.17 and 15.91 inches at Billings, Miles City and Sheridan, repsectively. Intense rainfall is produced only by severe cyclonic storms and thunderstorms.

Annual precipitation of snow and ice pellets averages approximately 55, 32 and 68 inches at Billings, Miles City and Sheridan, respectively, Table 38. A maximum of about 42 inches occurred during April 1955 at Billings.

Prevailing winds are generally from northwest, west northwest, and west (Table 39). During August, September and October, winds are from the southeast. Winds are strongest in March and weakest in December. From a dispersion standpoint, diffusion is good and the Colstrip terrain approximates the areas for which the diffusion equations were developed.

Humidity varies with wind direction. Humidity is low when winds are from the southeast and higher when winds are from the west or northwest. The relative humidity is lowest in the afternoons and highest at night. Relative humidity data are available for Billings, Miles City, Sheridan and Colstrip for the periods of 12, 10, 17 and 1 year, respectively, Table 40. Low humidity values occur during July and August, and high values occur during the winter season for all four stations. The average annual humidities for Billings, Miles City, Sheridan and Colstrip are 56, 62, 61 and 60 percent, respectively.

TABLE 36

MONTHLY TEMPERATURE SUMMARIES

	Maximum, °F				Minimum, °F				Mean Monthly, °F			
	Billings	Miles City	Sheridan	Colstrip	Billings	Miles City	Sheridan	Colstrip	Billings	Miles City	Sheridan	Colstr
No. Yr. Record	30	30	30	1	30	30	30		30	30	30	1
Month												
January	33.2	27.4	34.0	19	13.1	5.6	8.6	15	23.2	16.5	21.3	16
February	36.0	31.8	36.4	29	15.3	8.7	11.1	20	25.7	20.3	23.3	25
March	43.4	42.3	42.9	45	24.0	19.4	19.1	32	33.7	30.9	31.0	38
April	57.4	58.6	56.3	52	34.6	32.8	30.8	39	46.0	45.7	43.6	44
May	68.1	70.6	66.8	62	45.4	44.1	40.4	49	56.8	57.4	53.6	55
June	76.0	78.5	75.4	75	54.1	52.6	48.4	58	65.1	65.6	61.9	67
July	88.5	90.2	87.1	72	60.8	60.4	55.5	60	74.7	75.3	71.3	57
August	85.2	87.5	85.6	78	58.6	57.7	53.4	59	71.9	72.6	69.5	69
September	73.5	75.2	74.1	63	47.3	46.7	43.4	45	60.4	61.0	58.8	55
October	61.6	62.4	62.3	50	37.3	35.5	33.2	35	49.5	49.0	47.8	42
November	45.0	43.5	46.1	43	25.2	21.7	20.6	31	35.1	32.6	33.4	37
December	38.6	33.6	38.5	23	18.2	12.8	14.0	14	28.4	23.2	26.3	18
Year	58.9	58.5	58.8	51	36.2	33.2	31.5	38	47.5	45.8	45.2	45

TABLE 37

RAINFALL DATA

No. Yr. Record	Location and Parameter	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	Mean Total													
30	Billings	0.54	0.60	1.05	1.31	1.88	2.55	0.90	0.90	1.19	1.09	0.63	0.59	13.23
30	Miles City	0.44	0.37	0.65	1.06	1.73	2.71	1.34	1.24	0.96	0.87	0.43	0.37	12.17
30	Sheridan	0.64	0.74	1.42	2.16	2.57	2.57	1.19	0.9	1.17	1.13	0.80	0.62	15.91
	Maximum Monthly													
37	Billings	2.23 1963	1.66 1958	2.70 1954	4.42 1955	4.93 1942	7.64 1944	3.12 1958	3.50 1965	4.99 1941	3.80 1971	1.92 1959	1.89 1955	
33	Miles City	0.96 1965	1.30 1959	1.83 1950	2.82 1969	5.33 1955	9.78 1944	4.58 1948	4.00 1951	4.67 1941	3.20 1946	1.33 1964	1.78 1968	
31	Sheridan	1.70 1948	2.68 1955	3.26 1946	4.80 1963	5.20 1970	9.54 1944	3.78 1958	3.02 1968	3.08 1951	3.16 1971	2.23 1942	2.03 1955	
	Minimum Monthly													
37	Billings	0.04 1941	0.13 1954	0.13 1936	0.06 1962	0.53 1937	0.24 1961	0.10 1964	0.05 1955	0.06 1964	0.02 1948	Trace 1954	0.05 1957	
	Miles City	0.08 1961	0.08 1954*	0.07 1959	0.10 1952	0.24 1958	0.84 1961	0.22 1959	Trace 1967	Trace 1960	Trace 1965*	0.02 1953*	0.02 1957*	
31	Sheridan	0.12 1961	0.10 1941	0.24 1960	0.60 1960	0.30 1958	0.28 1971	0.08 1959	Trace 1970	0.06 1964	0.02 1965	0.15 1951	0.23 1951*	
	Maximum in 24 hr													
37	Billings	0.84 1962	0.61 1952	0.97 1945	0.48 1955	2.83 1952	2.78 1937	1.87 1958	2.47 1965	2.19 1966	1.93 1937	1.37 1959	0.71 1955	
	Miles City	0.42 1944	0.77 1952	0.61 1944	1.36 1947	2.39 1955	2.71 1964	2.02 1962*	1.65 1943	2.67 1941	1.38 1953	1.18 1957	0.50 1941	
31	Sheridan	0.88 1948	1.10 1955	2.25 1946	3.84 1948	2.04 1956	3.44 1944	2.28 1948	1.71 1943	1.33 1947	1.38 1953	0.86 1942	0.54 1946	

Also on earlier dates, months, or years.

TABLE 38

SNOW AND ICE PELLETS DATA

No. Yr. Record	Parameter and Location	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Tota
	Mean Total													
37	Billings	8.4	8.5	10.0	7.8	1.2	0.1	0.0	0.0	1.0	3.1	6.3	8.2	54.6
30	Miles City	6.2	5.6	5.4	3.4	0.5	0.1	0.0	0.0	0.1	1.4	3.8	5.2	31.7
31	Sheridan	9.9	11.3	12.9	9.2	1.7	0.2	0.0	0.0	0.8	3.6	8.6	9.6	67.8
	Maximum Monthly													
37	Billings	27.7 1963	22.3 1955	27.6 1935	42.3 1955	7.7 1967	2.0 1950	0.0	0.0	6.3 1961	23.6 1949	21.9 1959	28.8 1955	
30	Miles City	14.7 1949	19.0 1949	17.8 1967	16.6 1967	8.6 1967	2.0 1950	0.0	0.0	3.0 1941	12.6 1949	14.6 1955	18.0 1963	
31	Sheridan	23.9 1963	35.0 1955	36.8 1954	39.6 1955	11.0 1943	4.0 1969	0.0	0.0	9.5 1970	14.8 1971	25.8 1964	27.6 1955	
	Maximum 24 hr													
33	Billings	9.7 1962	9.0 1944	10.5 1964	23.7 1955	5.7 1967	2.0 1950	0.0	0.0	6.3 1962	10.0 1949	15.3 1959	13.0 1955	
17	Miles City	7.5 1964	6.5 1952	5.0 1957	10.5 1947	2.0 1953	2.0 1950	0.0	0.0	0.7 1950	3.8 1946	8.0 1964	7.0 1958	
31	Sheridan	11.2 1969	11.0 1955	13.3 1946	26.7 1955	7.3 1954	4.0 1969	0.0	0.0	5.5 1970	7.8 1949	12.0 1942	8.6 1960	

TABLE 39

AVERAGE MONTHLY WIND DATA

	Average Hourly Speed, mph				Prevailing Direction			
	Billings	Miles City	Sheridan	Colstrip*	Billings	Miles City	Sheridan	Colstrip*
No. Yr. Record	32	21	31	1	15	14	15	1
Month								
January	12.9	9.2	7.7	10.2	SW	NW	NW	WNW
February	12.4	9.3	8.0	12.2	SW	NW	NW	W
March	11.6	10.5	8.9	15.6	SW	NW	NW	W
April	11.8	11.6	9.9	12.2	SW	NW	NW	W
May	11.1	10.9	9.0	12.9	NE	SE	NW	NW
June	10.4	10.1	8.1	13.3	SW	SE	NW	NW
July	9.8	9.4	7.2	12.2	SW	SE	NW	NW
August	9.6	9.5	7.3	11.6	SW	SE	NW	SE
September	10.4	9.7	7.6	11.1	SW	NW	NW	SE
October	11.2	9.6	7.5	9.8	SW	SSE	NW	SE
November	12.3	9.7	7.8	12.9	SW	SSE	NW	WNW
December	13.0	9.6	7.5	9.4	WSW	SSE	NW	NW
Year	11.4	9.9	8.0	12.0	SW	SE	NW	NW

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*Wind speed and direction were measured on a meteorological tower at a height of 307 feet above grade.

TABLE 40

RELATIVE HUMIDITY, DIURNAL VARIATION AND MONTHLY AVERAGE IN PERCENT

No. Yr. Record	Time and Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year Average
	0500													
12	Billings	66	66	69	70	72	75	64	58	67	62	66	65	67
10	Miles City	72	81	79	78	77	78	70	63	73	72	78	76	75
17	Sheridan	73	74	77	77	79	81	72	70	73	73	75	73	75
1	Colstrip	65	76	69	69	68	69	62	74	72	82	80	74	72
	1100													
12	Billings	61	59	54	51	49	50	39	38	50	48	57	62	52
10	Miles City	69	72	63	54	49	47	39	36	48	48	64	70	55
17	Sheridan	62	61	59	48	48	49	36	35	40	44	57	61	50
1	Colstrip	57	62	45	42	45	37	43	39	41	52	53	59	48
	1700													
12	Billings	58	54	47	43	43	44	31	28	40	40	53	58	45
10	Miles City	68	70	55	47	44	41	31	27	39	44	62	69	50
17	Sheridan	66	64	61	46	48	48	35	32	39	47	65	68	52
1	Colstrip	65	65	52	45	43	37	41	36	37	55	66	65	51
	2300													
12	Billings	64	64	63	61	61	63	50	44	56	54	62	64	59
10	Miles City	72	78	74	69	66	66	54	47	61	62	74	75	66
17	Sheridan	71	73	74	70	71	74	62	58	64	66	73	71	69
1	Colstrip	69	74	73	71	69	66	55	68	64	79	77	73	65
Monthly Average	Billings	62	61	58	56	56	58	46	42	53	51	60	63	56
	Miles City	70	75	68	62	59	58	49	43	55	57	70	73	62
	Sheridan	68	68	68	60	62	63	51	49	54	58	68	68	61
	Colstrip	64	69	60	57	56	52	50	54	54	67	69	68	60

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2. Climate of Wyoming, Climatography of the United States, No. 60-48, U.S. Dept. of Commerce Weather Bureau, Washington, D.C. U.S. Government Printing Office, Washington, D.C. 20402, 1960.

3. Local Climatological Data, Annual Summary with Comparative Data, Sheridan, Wyoming, U.S. Dept. of Commerce, NOAA, Environmental Data Service, Silver Spring, Maryland. U.S. Government Printing Office, Washington, D.C. 20402, 1971.

4. Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years, U.S. Department of Commerce Weather Bureau, Technical Paper No. 40. U.S. Government Printing Office, Washington, D.C. 20402, 1963.

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6. Glaze Its Meteorology and Climatology, Geographical Distribution and Economic Effects, Quartermaster Research and Engineering Center, Environmental Protection Research Division, Natick, Massachusetts, Technical Report EP-105, March 1959.

5. EFFECT ON VEGETATION

As an inevitable result of surface-mining operations, vegetation will be temporarily eliminated from the immediate mining area. Without reclamation, Colstrip's mined lands could take 30 or more years to re-establish a vegetative community by natural succession. With proper reclamation techniques, however, this process is expected to be accomplished in only a small portion of that time.

The rate at which mined lands are naturally restored depends on their surface condition when mining ceases. In the past these areas were not reclaimed but left with high naked ridges and steep slopes which are subject to erosion and experience slumpage and exposure to toxic materials. Under these conditions natural succession proceeds very slowly. The few plants that first invade the area are eroded away before they can become firmly established. Primary and secondary succession normally take thousands of years to bring the area back to the original, premined condition.

A productive vegetative cover can be formed in one growing season by the application of nutrients to raw spoils material and the use of surface treatments such as shaping gouging and chiseling.

The primary requirement of reclamation is that surface-mined lands never permanently cease to be useful and productive. The aim of preplanned reclamation objectives for Colstrip is that eventual biotic stability and acceptable productivity follow strip-mining activities and that the area's livestock grazing capacity become equal to or greater than its capacity before mining began.

Because no reclamation program in Montana has yet achieved this level of success, sound evidence must be presented to justify the belief that successful reclamation is possible at Colstrip. In the southeast corner of Section 35, east of the Old Burlington Northern Coal Pit #3, is a three-acre area of raw spoils left after surface mining ceased about 30 years ago and now worn smooth by weathering. MAES range scientists recognized that natural succession had taken place in this undisturbed area which is not apparently distinguishable from surrounding unmined rangeland.

A small portion of the area ($40m^2$) has been fenced off as a study plot, and productivity and cover analyzed. Several stands of ponderosa pine (approximately 4-5 feet tall) dominate the area, silver sagebush and rubber rabbitbrush shrubs are abundant (approximately 17 percent cover), and perennial grasses are hardy and vigorous (approximately 20 percent cover). Total production is about 1200 lbs/acre, and seed mixes used on WECo dryland pasture reclamation have produced 1483.5 lbs/acre.

Other untreated Burlington Northern mine spoils within the Western Energy Company property boundary support a varied and stable cover of native grasses, forbs, shrubs and trees. Productive stands of Indian ricegrass, western wheatgrass, rubber rabbitbrush, yellow sweet clover and other native species grow on the mounded spoils where toxic materials have not been exposed and where the slope is not excessive. These abandoned spoils have been used for livestock grazing and for wildlife food and cover for many years.(2)

REFERENCES

1. Brian Sindelar letter communication to Peter R. Edmonds, August, 1973.

2. "Surface Mined Land Reclamation Research in Montana," Progress Report 1972-1973, Montana Agriculture Experiment Station, Montana State University Research Report No. 40, April, 1973.

6. EFFECT ON WILDLIFE

Annual populations will be completely disrupted or sharply reduced in size in the immediate mining area. Animals will be forced to migrate to adjacent habitats where they must compete for food and cover. These nearby areas have to adjust to such environmental changes until biotic stability is restored. However, these adverse effects of surface mining at Colstrip are expected to be temporary, subject to long term, but are able to be effectively reversed through proper reclamation.

Big game animals will be displaced from the area of active mining. Proper reclamation, if providing an arrangement of vegetative communities similar to the natural one which has or now exists, should result in the return use by mule deer and antelope.

Strip mining would destroy all small mammal and game bird habitat. Larger non-game mammals such as the red fox and coyote would vacate strip-mined areas because of the lack of smaller prey species. The small mammal populations would invade the mined area within a short time followed by the predators. This has occured in the Pit 6 area to such an extent that mammal activity and growth presents a problem to reclamation. The return of the game birds would depend on the restoration of their habitat with native vegetation.

Mining activities are not expected to have much of an impact on the migratory waterfowl of the area, other than to disrupt their use of some water areas as resting and feeding areas during migration. Some of these water areas or ponds may be destroyed as a result of mining, but other suitable areas could be created to compensate for this during reclamation.

Non-game bird species will be affected primarily by the removal of nesting habitat for some species. Proper reclamation will replace the habitat removed.

All species of fish amphibians and reptiles, associated with the existing water areas would be eliminated during mining activities if these ponds are filled. With proper reclamation they would return and fish could be restocked depending on water conditions. Mining activity is not expected to adversely influence Armells Creek because of the special separation of the two areas. No mining is planned within a minimum of 50 feet of Armells Creek.

Insect populations would be adversely affected but would return as their habitat is re-established.

Mining activities are not expected to affect any rare or endangered species.

7. IMPACT OF STRIP MINING ON GROUNDWATER

Local groundwater may be affected by strip-mining operations of the Rosebud seam, by strip mining the shallow sandstone aquifer, by manipulating the natural condition of local soils or by exposing piles of coal, topsoil and overburden to rain and runoff.

Three important aquifers are located in the upper 200 feet of the Colstrip mining area: The Rosebud coal seam contains the highest quality groundwater; the McKay coal seam has water of poorer quality; and when located below the water table, the sandstone bed overlying the Rosebud seam is a significant aquifer but of poor quality. In the Tongue River member sandstone beds, below the coal seams, lie several productive aquifers with fair water quality from which the town of Colstrip and many farmers draw their water supply.

1. Impact on the Rosebud Aquifer

During mining, flow within parts of the Rosebud aquifer will be mechanically stopped, which will reduce the flow in the seam downdip from the mined area. In downdip wells supplied by this aquifer, the water level will drop. But, an inventory of known wells based on the U.S.G.S. and other sources [See S10300 2e(i)] present groundwater study in the area reveals that there are very few (less than three) wells in the area (three miles downdip and one mile in each direction of the 1974 mining area) that may be affected, because the outcrop of the coal is downdip.

When mining and refilling are completed, the groundwater flow should partly resume through the loosely compacted overburden in the mined area; but since the clay rich overburden has a lower permeability the resumption of groundwater flow through this material has been questioned. The hydrological study conducted for this report,(1) however, indicated that groundwater is present in the existing spoils and that the flow through the mined area will be restored.

Comparison of water quality in the Rosebud aquifer in 1923, which predates commercial mining activity near Colstrip, and in 1973 reveals no major differences, indicating that the strip mining of the Rosebud seam for the past 50 years has not significantly affected the general aquifer quality.

2. Impact on the McKay Aquifer

Strip mining the Rosebud seam in this area should not affect the McKay aquifer. The groundwater system in this area, where aquifers are separated by poorly permeable clay strata, is characterized by very slow vertical and lateral flow. Although the overburden replacing the coal in the Rosebud seam will decrease this flow even more, the McKay aquifer should not be affected since it is mainly recharged updip from the mined area and is almost absent downdip. The inventory of known wells in the area (three miles downdip and one mile in each direction of the 1974 mining area) reveals that there are no known wells that draw water from the McKay seam that could be affected.

3. Impact on the Shallow Sandstone Aquifers

While the mining operation will disturb the shallow sandstone aquifer in the Rosebud overburden, only wells located updip from the mining area may be affected since this aquifer is absent downdip. The 1973 hydrological study(1) reveals that within 3 miles of Pit No. 6 there were no known wells updip. The presence of water in the unreclaimed spoil banks indicates that the shallow groundwaters will be restored after reclamation. But these new aquifers will have poorer quality water primarily because new, fresh mineral surfaces will be exposed to the groundwater leaching process. Experiments show that as minerals come in contact with aqueous solutions a rapid leaching reaction is followed by a slow diffusion process.(2) That is, the initial quality of groundwater in the reclaimed area will be of poorer quality than the groundwater in unmined shallow aquifers. With time, as leaching occurs, the quality of these aquifers will improve.

The lowering of groundwater quality can also degrade the quality of surface water. Downdip from Colstrip, the water quality of east Armells Creek indicates that groundwater escapes from the spoil banks into the creek. The effect, however, is local and the water quality should improves further downstream as groundwater is diluted by water of relatively better quality.

4. Impact on the Sandstone Aquifer Underlying the Rosebud Seam

The Tongue River member sandstone aquifers, located below the coal seams, will not be affected by the strip mining operation. These productive aquifers serve the town of Colstrip and many farmers in the area, and could be a source of groundwater to replace the few wells that may be affected by the 1974 mining operation.

5. Impact of Reclamation on Groundwater

Reclamation research(3) shows that revegetation of the Colstrip area can be greatly enhanced by surface manipulation of spoils to trap precipitation and by placement of surficial permeable materials to aid infiltration. Encouragement of perculation to the base of the spoils by these activities has been a hydrologic concern.(1) However, since precipitation is low and evaporation high, significant contamination of deep aquifers from topsoil or soil bank leaching or from added nutrients may reach the very poor quality shallow groundwater and flow with them to East Armells Creek.

Nutrients will be added only for a limited period of time, and the quantity of perculating water will be reduced as soon as a permanent revegetated cover is established.

6. Impact of Spoil Bank Runoff

a. Groundwater

Spoil bank ponds contain water rich in calcium, magnesium and sulfate ions, with magnesium concentrations surprisingly higher than those in any other waters in the area. The fact that the ponds' salt concentrations increase during warm, dry months rather than during cold, wet months, when runoff occurs, indicates that the spoil bank runoff is of better quality. Contamination comes from the slow, year-round leaching of the spoil banks. High rates of evaporation during hot weather increases salt concentrations.

The short, intense local showers do not allow the rainfall enough time to soak into the surface soil where it could dissolve some ions. Rather the rainfall runs off the surface as a relatively unmineralized solution, which improves the quality of the local ground or surface water.

b. Surface Salt Accumulation

Affected runoff water will be limited to that from the two spoils banks exposed at any given time. Maximum exposed surface is estimated at 70 acres in each operating area. Net runoff, based on the annual mean runoff of 0.25(1) inches per year, is consequently of the order of 50 gallons per hour in each area. The mean annual discharge of Armells Creek is 6.6 cfs. It follows that dilution of rainfall penetrating the spoils banks and entering Armells Creek will exceed a factor of 3000 times. Rosebud Creeks mean annual flow rate of 24 cfs(2) will allow a still greater dilution. The quality of water in Armells and Rosebud Creeks will not be affected measurably.

The limiting of spoils banks area is the active precaution which will be taken to prevent erosion and damage to land and water.

Experiments with minerals show that alternate wetting and drying causes salt buildup on newly exposed surfaces.(2) The low rainfall in the Colstrip area can wet the surface and during the long dry periods, capillary forces may draw ions to the surface where they can react with each other and with the atmospheric carbon dioxide. to form relatively insoluable salts. The local soils being rich in calcium, magnesium and sulfates, could produce calcium and magnesium sulfates and carbonates. Reclamation in this area has shown that salt accumulation did not prevent successful reclamation, even on spoil surfaces lacking topsoil. Because topsoil will cover all reclaimed areas, the salt accumulation either will not occur or will not affect successful reclamation.

7. Impact of Coal Stockpiles on Ground and Surface Water

There has been some concern that acid drainage due to runoff from coal stockpiles may contaminate groundwater and surface water, but such drainage either will not occur or will be chemically neutralized. Little runoff of this type is expected and any which does occur will be neutralized chemically.

Acid mine drainage results when sulfuric acid slowly forms from the oxidation of pyrite or marcasite coal inclusions in the presence of water. At Colstrip, the coal stockpiles will be compacted to reduce the quantity of oxygen present, thus reducing the oxidation of the iron sulfide minerals. In addition, the small amount of rain at Colstrip is probably insufficient to form sulfuric acid and carry it to nearby soils. If acid mine drainage should occasionally occur, it would probably be neutralized by the loca basic soils. Nevertheless, stockpile runoff will be monitored and, if it occasionally proves acidic, it will be diverted to a treating tank where it will be neutralized by conventional methods. Laboratory tests indicate, however, that water exposed to Rosebud coal becomes more nearly neutral.

MONITORING THE IMPACT OF STRIP MINING ON GROUNDWATER

The Western Energy Co. is presently partially sponsoring a long-term comprehensive hydrological study conducted by the Division of Hydrology of the Montana Bureau of Mines and Geology. The project began on July 1, 1973. Monitoring the quantity and quality of the groundwater at the mining area is part of this program.

The contract between Western Energy Company and the Montana Bureau of Mines and Geology contains the following details regarding the programs procedures:

"Procedures for the first two years of the proposed study are as follows:

A. Field procedures:

1. General hydrologic reconnaissance of the Colstrip area.
2. General inventory of existing wells in the area.
3. Collection of water samples from selected wells and stream locations.
4. Installation of weirs and monitor equipment at selected stream locations.
5. Installation of observation wells at selected locations.
6. Installation of recorders and shelters on selected observation wells.

B. Office procedures:

1. Examination of available water data (county records, well driller's logs).
2. Analysis of water samples.
3. Compilation of data.
4. Completion of initial report.

Procedures during the third year will include monthly collection of water samples at selected locations and collection of records from monitored weirs and wells. During the third year of work, plans and budgets for succeeding years of sampling and monitoring will be negotiated by Western Energy Company and the project representative if deemed necessary."

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5. Catalogue of Stream Gaging Stations in Montana, Inventory Series Report No. 6, Revised October 6, 1972, Montana Department of Natural Resources and Conservation, Water Resources Division.

8. LAND USE

1. AREA E-1

There are four general categories of land use which occupy the 249.9 acres of Area E-1. In order of decreasing areal extent they are rangeland, stripped land, savanna (ponderosa pine), and roads. The first of these, rangeland, occupies 55 percent (137.4 acres) of E-1. The land has a potential for cattle grazing, although at present it is not used for this activity. Proper restoration will return this potential.

A significant section of the area is composed of previously stripped land. This section is 39 percent (97.2 acres) of E-1 and extends along the entire northern and eastern boundaries of the area. There are also scattered sections of ponderosa pine savanna which in total amount to 6 percent (15.3 acres) of Area E-1. These sections tend to be associated with elevated rock outcrops and are in general along the western boundary of E-1.

The final category of land use considered here is roads. Three light-duty dirt roads cross parts of Area E-1, but their acreage is negligible.

2. PIT 6

The nearly 121 acres being considered for mining near Pit 6 are currently in low intensity use. Almost 97% of the land at this site is short-grass prairie suitable for cattle grazing. The remainder supports a sparse growth of Ponderosa pine interspersed with short-grass. Proper restoration will return this potential.

3. Area A-1

Although the categories of land use are somewhat different in this area than in the other two, the overall pattern is again simplistic.

The total area of A-1 is 983 acres, most of which is rangeland. In fact, 577 acres or 58.8 percent of the total area of A-1 may be classed as short-grass rangeland. This location differs from Pit 6 and area E in that the rangeland is most probably used for grazing as there are extensive farms nearby.

These farms, or more correctly their fields of forage crops cover 279 acres (28.3%) of Area A-1. These fields are non-irrigated and are primarily in the southern and eastern sectors of A-1. Proper restoration and judicious use of soil additives should return these areas to present levels. Finally, ponderosa pine uplands are dispersed throughout the western and northern sectors of the area. This land is not in use for the trees are too sparce and of too poor quality for commercial use. These uplands occupy the remaining 127 acres (12.9%) of Area A-1.

AREA E-1

LAND USE

	Acres	Percentage of Total
Rangeland	137.4	55.0
Stripped land	97.2	39.0
Ponderosa pine	15.3	6.0
Total	249.9	100.0

PIT 6

	Acres	Percentage of Total
Ponderosa Pine	4.00	3.3
Rangeland	116.75	96.7
Total	120.75	100

AREA A-1

	Acres	Percentage of Total
Rangeland	577	58.8
Cropland	279	28.3
Ponderosa pine	127	12.9
Total	983	100.0

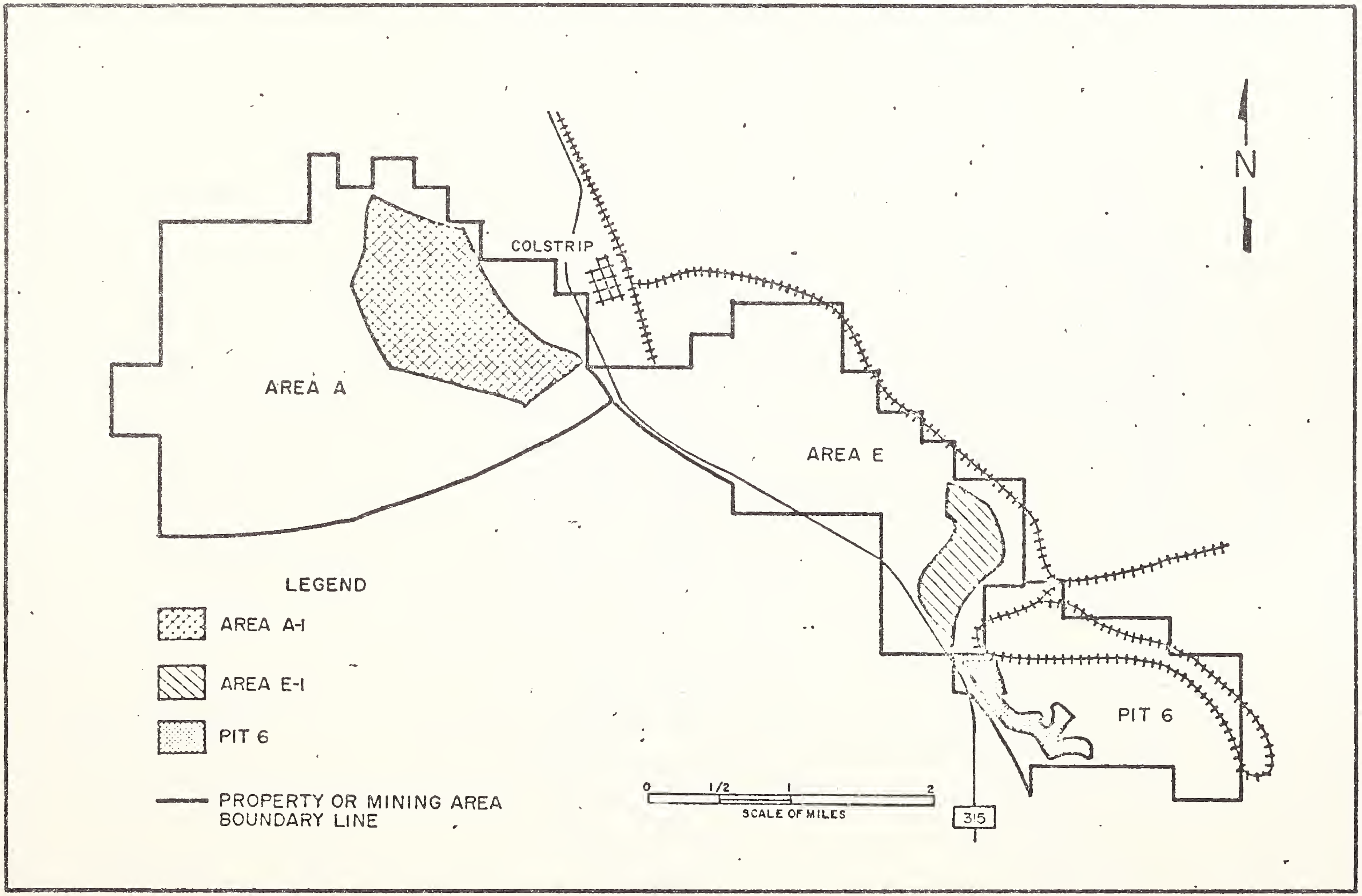
N
COLSTRIP
AREA A
AREA E
PIT 6
315
LEGEND
AREA A-1
AREA E-1
PIT 6
PROPERTY OR MINING AREA BOUNDARY LINE
0
1/2
1
2
SCALE OF MILES

Figure 10 LAND USE STUDY AREAS

8. SOCIOECONOMIC IMPACT

DESCRIPTION OF OPERATIONS AND SOCIOECONOMIC STRUCTURE

Western Energy Company (WECo.) began mining coal at Colstrip in 1968. In 1972 long-term contracts were entered into that necessitated expanding the Colstrip mining operation. Preparation for this expansion is now underway with operation to begin in October, 1974.

In 1973 the average employment at the mining operation was 130 people. During 1974 some of WECo.'s short term contracts will be terminated allowing for production of only 2,400,000 tons. Even with this decrease in production employment will increase to 185 people due to the erection of mining machinery and the start-up of operations in mining Area A. Coal from Area A will supply long-term contracts for the purpose of electric power generation.

The town of Colstrip was originally constructed in the 1920's and 30's to house families of people employed mining coal for Northern Pacific Railway Company's steam locomotives. In 1959, when Montana Power Company purchased the Colstrip properties the town was part of the deal. This town will be enlarged to accommodate people working in the expanded operations at Colstrip.

Future plans call for large expansion in mining to meet the contracted coal supply committments as well as the coal needed to operate a steam-electric generating plant at Colstrip for the parent company, The Montana Power Company. Construction activities for this plant and the associated mining preparations have been initiated and are presently in progress.

Mining at Colstrip began in 1923. The present, historical and projected mine production rates are given in Table 41.

GENERAL CONSIDERATIONS

The expected production level of about 2.4 million tons of coal is approximately 50% below the presently established operating level. The manpower requirements at the existing mining operation will decrease in 1974 to 125 miners. The expanded mining operation in Area A will produce 400,000 tons of coal and employ about 60 people. However, significant social and economic changes are in process as a result of the construction and mine preparation activities for future operation at the Colstrip power plant. The socioeconomic impact of the mining production in 1974 will be insignificant in comparison to the growth and impact of plant construction and preparations. The impact of failure to be licensed for production could however be significant from the social and economic views. At present, the employment for mining production constitutes the stable base for the Colstrip community. The impact of failure to license the mining would be the serious disruption of both the community and the mining preparations for the future.

Production levels in the 1971-1975 period are shown to be relatively constant, with the exception of 1974 when the production level is anticipated to be somewhat lower than in other years. During 1974, much of the mining will be shifted from Pit 6 to Areas A and E, which accounts for the drop in production. Yet manpower required in 1974 will increase, rather than drop, due to mining preparation activities.

In 1972, the population of the town of Colstrip was 770 and the school enrollment was 277. By September, 1973, the population had grown to about 1500. The total school enrollment level reached about 520. A period of exaggerated growth had been initiated due to the construction activities for the new power plant.

The various socioeconomic impacts of the mining will be presented in the next sections.

TAXATION

There are several types of taxes which would produce revenues from the mining operations. They include ad valorem, net proceeds, indemnity trust fund, strip mine license and corporate license taxes. The total taxable values and revenues are presented in Table 42. The net proceeds tax for the calendar year is paid in November of the following year; i.e., tax for 1974 will be paid in November 1975. The property tax is paid in May and November.

Western Energy Company would not qualify for the three year tax write-off. This write-off applies to: (1) new industry which has not been involved in business in Montana in the past, or (2) pollution control equipment.

LABOR FORCE

The labor requirements expected for 1974 are about 185. The history of the labor force size and future expectations are given in Table 43. The size of the labor force is related to both the production level and the needs for site preparation for future mining. On initially moving into a new mine area, the manpower utilization efficiency is not high. Thus, while production expectations for 1974 are relatively low, the transition of mining operations to new areas and the preparation of site and equipment for future operations will require increases in the manpower required. Beyond 1974, additional requirements of manpower are needed for coal mining operations related to the new plant.

Detailed information on the composition of the work force is not now available for the present or anticipated employees. However, some reasonable assumptions can be made about the composition of the labor force based on state-wide census information. About 75% of the employees would likely be in the age range of 20 to 44 years old. Most of the employees would be expected to be married, with about 20% being single. The average family size is 3.9 persons. The typical educational level would be high school with some job training.

In 1972 Long Construction Company, the contractor mining the coal for Western, surveyed the 159 miners working at the mine and found only 11 (7%) were from out of state - 10 from northern Wyoming. The remainder, 148 miners, were Montanans, 87 were from the Forsyth, Colstrip and Lame Deer area. Thirty-one were from the Billings area, 19 from other parts of eastern Montana and 11 from western Montana. This survey plus applications received for future jobs suggest that most of the workers who come to Colstrip will come from eastern Montana. A large number of the workers who come to the mine are displaced ranch and farm people. This is evidenced by the fact that from 1920 Montana's farm population has declined from 225,000 to 105,000 in 1960. Eastern Montana is experiencing a migration of young people who are forced to leave agriculture because the family farm is capable of supporting increasingly fewer persons. Jobs at Colstrip have and will continue to give these people an opportunity to stay near the home land.

COMPANY PROVIDED SERVICES

The townsite of Colstrip is owned by Western Energy Company. The company has programs to provide needed community services. An urban plan has been developed for the town of Colstrip by Ken R. White and Associates of Denver. This plan is already being followed by the Montana Power Company and Western Energy Company.

The existing town sewage system is composed of two lagoons for primary treatment and one for secondary treatment. This sewage treatment facility was redesigned in 1971 to serve the estimated projected population growth for the surrounding growth area. The facility was increased in size by about 50 percent.

Western Energy is constructing a community center that is projected to cost $350,000 and will be completed early in 1974. It will contain an eight lane bowling alley, large meeting-social area and kitchen facilities. A $589,000 commercial center was started in September, 1973. It will contain a grocery store, hardware-sporting goods store, barber and beauty shops, laundromat, post office, medical and dental facilities and space for professional offices and various businesses. A $133,000 utilities project is also scheduled. This will include installation of water and sewer lines, sidewalks and initial street construction. Street paving is also scheduled.

On numerous occasions, attempts have been made to include locally residing Indians in the training programs. One Northern Cheyenne Indian has been employed and trained by Western Energy Company. The management of Long Construction Company, the contractor mining the coal for Western Energy, has requested the Indians to attend training schools.

Western Energy Company provides a licensed, fully equipped ambulance for use at the mine, in the town of Colstrip and the immediate areas. This service is provided at no cost to the individual who uses the service.

There is a nurse in the area that has an arrangement with doctors in Forsyth to provide medicines and recommend a patient to either of these doctors.

In the Commercial Center to be constructed in the near future, there is space provided for medical and dental facilities. Although a number of doctors have investigated the prospects at Forsyth and Colstrip, none has decided to locate in either area. Western Energy continues to work with the county commissioners and area doctors to encourage a doctor to locate in the area.

IMPACT ON OTHER ECONOMIC ACTIVITIES

The socioeconomic impact of the proposed mining for 1974 will be essentially the same as the impact of mining in the several previous years. For the most part, there will not be significant changes in local social and economic patterns that will result from the mining. The big changes will occur as a result of the construction operations for the Colstrip power plant, units 1 and 2. The impacts would not be expected to be adverse, but rather a continuation of existing effects and circumstances.

The disturbance of about 185 acres in 1974 would not have a particularly significant effect on the local natural resources, such as coal, water and land. The coal resources will be depleted by 2.4 million tons, the amount to be mined. Large amounts of water will not be needed and there will be no discharges of liquid effluents which could contaminate either the local streams or the ground water. The disturbed land will be reclaimed and restored to productive use in accordance with the State requirements. During mining operations, however, it will be disrupted. Approximately 20% of this land, or less than 40 acres, is cropland and the remainder is rangeland. Based on typical economic valuations of $10 per acre for 5 years, the economic loss value of these lands would be anticipated to be about $2000 at the greatest.

Most of the land that will be disturbed by Western Energy Company's mining operation is owned by either the Burlington Northern, local ranchers, the State of Montana, or the federal government. Western Energy Company has been negotiating with local ranchers to purchase the land outright. In some instances, land has been purchased in another area and traded for land underlying the coal. Arrangements are being made with the Burlington Northern and state and federal governments to either secure a lease or purchase lands for mining. After the land has been reclaimed, Western Energy will manage the lands until the reclamation process has been completed, a period of approximately five (5) years. At this time land will be either turned back to the original owner or sold to local ranchers for use as grazing and agricultural lands.

Since the expected production and employment levels for 1974 are not drastically different from those levels in 1973, the limited commercial enterprise and transportation facilities would not be impacted significantly by the 1974 mining. However, examination indicates that the most significant impact will result from the other occurring activities, namely construction. Even so, the increased local population at this time (1974) will not seriously overburden the stores and traffic facilities.

The 1974 labor force is expected to be about 185, which is a moderate increase over the present employment level. The present mine payroll is approximately $1.5 million and this would increase to about $2.5 million in 1974. The local personal income from indirect jobs is less than $2.5 million and will increase slightly in 1974 due to mining operations. It is estimated that for each ten jobs created in the mining industry, 17 jobs are created in support service and other enterprises. These additional jobs, numbering about 300, result indirectly from the operation of the mine. Thus, the total number of jobs resulting from mining will be nearly 500 in 1974.

IMPACT ON COUNTY AND COMMUNITY

Much of the labor force needed to work at the mine in 1974 is already so employed. These employees and their families for the most part are already living in Colstrip and other communities within commutive range. Those children constitute the majority of the present school enrollment. It is expected that new employees will be needed for the 1974 mining operations, so that some direct impact of the mining on the schools will occur. However, the actual mining impact is only a part of the total socioeconomic structure. The construction activities will have a very significant effect on the school system. The impact contribution of mining labor force families on the school system is an integral part of the total impact on the school system, even though it may be a relatively small part and the base portion of the impact.

No significant impact will be anticipated with respect to state and county roads in the area or upon recreational, civic, religious, law enforcement and other social and government services. Some impact will result from the increased number of employees and their families, but this impact will be small in comparison to the impact of the total long-range mining and construction activities expected in 1974. There will be no need for dislocating any persons in conjunction with the strip mining operations of 1974.

The anticipated tax revenues for 1974 were presented in a previous section. The estimations for 1974 were based upon the 1973 taxation rate structure. It is shown that even with lower production the expected revenues of 1974 will be greater than 1973. The existing tax rates would cause a 10% increase in the tax revenues.

The tax policies of the county may be affected in the following way. There is a bill in the State Legislature now that would transfer the net proceeds tax out of the county and into the state coffers, which in Rosebud County will produce a taxable value loss of approximately $3 million. There is a projected change in the mill levy due to the increased taxable value of mining equipment and the net proceeds tax. When Western Energy Company came to Colstrip in 1968 the mill levy was 143 mills and it dropped until in 1972 the mill levy was 114 mills. However, in 1973 the mill levy did go up to 134 mills but it is anticipated that it will again drop in 1974.

At this time, specific impacts on public health programs and services are not known. Effluents from mining operations that could endanger public health would not be expected. Job training programs include concerns for job safety. A few more trucks and personnel will be expected on the local road because of the increased mine preparation activity. Since the roads are not presently overcrowded, this will not create a problem.

SOCIOECONOMIC IMPACT SUMMARY

The proposed mining for 1974 will not impact on the local community and the surrounding areas in a manner different from the impact of previous years. While increased employment and decreased production of coal are anticipated for the year's direct mining operations, the resulting impacts are small, especially in comparison to the impacts created in those communities by the construction activities associated with the power plant. For the most part, the impact of the productive mining in 1974 will be to provide a continuance of the established pattern and a stable base for the new activities associated with other projects.

TABLE 41

WECo MINE PRODUCTION

YEAR	TONS MINED
1968	150,000
1969	520,000
1970	1,660,000
1971	5,160,000
1972	5,500,000
1973	4,700,000
1974	2,400,000
1975	4,430,000
1976	10,090,000

TABLE 42

TOTAL LOCAL AND STATE COAL TAXES IN COLSTRIP, ROSEBUD COUNTY, MONTANA

The tax mill levy in Colstrip was 134 mills in 1973. This same rate is used for 1974 in the tax calculation estimates which follow.

AD VALOREM TAX

Ad Valorem Tax is a property tax assessed against the full cash value of the property reduced to 40% and then 30% in series. The county mill levy is then applied against the assessed value of the property.

Original purchase cost x 40% x 30% x 134 mills = Ad Valorem Tax
$9,800,000 x 40% x 30% x 134 mills = $157,600

NET PROCEEDS TAX

Net Proceeds Tax is an annual tax on the net proceeds of all mines and mining claims, after deducting only specified allowable expenses. It is assessed by the state but goes to the county where the coal was mined.

Value of coal sold = 2,400,000 tons @ $2.36/ton = $5,664,000

(Less) Operating Expenses @ 76¢/ton	$1,824,000	
Royalties @ 14.8¢/ton	355,200	
Marketing	250,000	
Betterments	506,800	
Repairs & Replace:		
Tipples & Picking Tables	24,000	
Depreciation of Tipples	103,500	3,063,500
	134 mills x	$2,600,500
		$348,500

STRIP MINE LICENSE TAX

A coal mining license tax is assessed against each ton of coal produced, based on the BTU content of the coal. The tax rate for the Rosebud seam is $0.34 per ton.

2,400,000 tons x $0.34/ton = $816,000

CORPORATION LICENSE TAX

Corporation License Tax is assessed against the net income of a corporation at the rate of 6 3/4%.

Gross Revenues = 2,400,000 tons @ $2.09/ton = $5,016,000

(Less)	Operating Expense @ 76¢/ton	$1,824,000	
	Royalties @ 14.8¢/ton	355,200	
	Lease costs	100,000	
	Reclamation	48,000	
	Administrative & General	250,000	
	Depreciation	1,107,200	
	Mining License Tax	168,000	
	Net Proceeds Tax	348,500	
	Interest	840,000	
	Ad Valorem Tax	157,600	
	Depletion	81,600	5,280,100

6 3/4% x (<0) = 0

Tax	1973	1974
Ad Valorem	$ 65,000	$ 157,600
Net Proceeds	557,800	371,800
Strip Mine License	329,000	816,000
Corporation License	129,600	0
	$1,081,400	$1,345,400

TABLE 43

EMPLOYEES AT WECo MINE

(Historical and Projected)

Year	Number
1972	143
1973	100
1974	185
1975	260
1976	275

APPENDIX D

COAL ANALYSIS REPORTS

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES: 228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601 • AREA CODE 312 726-8434

August 24, 1971

MAIL ADDRESS
16130 VAN DRUNEN ROAD
SOUTH HOLLAND, ILLINOIS
(CHICAGO) [illegible]
PHONE 312 [illegible]

NORTHERN TESTING LABORATORIES
P. O. Box 1561
Billings, Montana 54901

Sample Identification by
Northern Testing Laboratories

Sample No. A-1 18360-64

A & B.

Kind of sample reported to us -----

Sample taken at -----

Sample taken by Northern Testing Laboratories

Date sampled -----

Analysis report no. 71-396525

MINERAL ANALYSIS

	IGNITED
Phos. pentoxide, P_2O_5	0.14
Silica, SiO_2	31.94
Ferric oxide, Fe_2O_3	26.40
Alumina, Al_2O_3	15.50
Titania, TiO_2	0.57
Lime, CaO	8.48
Magnesia, MgO	3.22
Sulfur trioxide, SO_3	12.03
Potassium oxide, K_2O	0.85
Sodium oxide, Na_2O	0.65
Undetermined	0.22
	100.00

Silica Value = 45.60
T250 = 2180 °F
Mercury, Hg = 0.1 ppm - coal.

Charter Member

IOF:bvw

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

I. O. Foster

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES: 228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601 · AREA CODE 312 726-8434

August 24, 1971

NORTHERN TESTING LABORATORIES
P. O. Box 1561
Billings, Montana 59401

MAIL ADDRESS
16130 VAN [illegible]
SOUTH HOLLAND [illegible]
[illegible]
PHONE 312 [illegible]

Sample Identification by
Northern Testing Laboratories

Sample No. A-2 18365-68

Kind of sample reported to us ------

Sample taken at ------

Sample taken by Northern Testing Laboratories

Date sampled -------

Analysis report no. 71-396526

MINERAL ANALYSIS

	IGNITED
Phos. pentoxide, P_2O_5	0.22
Silica, SiO_2	40.73
Ferric oxide, Fe_2O_3	7.00
Alumina, Al_2O_3	16.67
Titania, TiO_2	0.95
Lime, CaO	12.15
Magnesia, MgO	3.80
Sulfur trioxide, SO_3	15.95
Potassium oxide, K_2O	0.86
Sodium oxide, Na_2O	0.70
Undetermined	0.97
	100.00

Silica Value = 63.96
T250 = 2390 °F
Mercury, Hg = 0.1 ppm (Coal)

Charter Member

IOF:bvw

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO

I. O. Foster

Certified

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES: 228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601 • AREA CODE 312 726-8434

August 24, 1971

MAIL ADDRESS
16130 VAN DRUNEN ROAD
SOUTH HOLLAND, ILLINOIS
(CHICAGO) 60473
PHONE [illegible]

NORTHERN TESTING LABORATORIES
P. O. Box 1561
Billings, Montana 54901

Sample identification by
Northern Testing Laboratories

Sample No. A-3 18369-72

Kind of sample reported to us -----

Sample taken at -----

Sample taken by Northern Testing Laboratories

Date sampled -----

Analysis report no. 71-396527

MINERAL ANALYSIS

	IGNITED
Phos. pentoxide, P_2O_5	0.08
Silica, SiO_2	45.31
Ferric oxide, Fe_2O_3	2.77
Alumina, Al_2O_3	17.84
Titania, TiO_2	0.76
Lime, CaO	14.58
Magnesia, MgO	4.30
Sulfur trioxide, SO_3	12.34
Potassium oxide, K_2O	0.81
Sodium oxide, Na_2O	0.53
Undetermined	0.68
	100.00

Silica Value = 67.67
T250 = 2465 °F
Mercury, Hg = 0.2 ppm → [illegible] per NTL

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

I. O. Foster

Charter Member

IOF:bvw

Certified

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES 228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601 • AREA CODE 312 726-8434

August 24, 1971

NORTHERN TESTING LABORATORIES
P. O. Box 1561
Billings, Montana 59401

Sample identification by

Northern Testing Laboratories

Sample No. A-5 18373

Kind of sample reported to us ------

Sample taken at ------

Sample taken by Northern Testing Laboratories

Date sampled ------

Analysis report no. 71-396528

MINERAL ANALYSIS

	IGNITED
Phos. pentoxide, P_2O_5	0.44
Silica, SiO_2	53.40
Ferric oxide, Fe_2O_3	2.30
Alumina, Al_2O_3	17.00
Titania, TiO_2	0.83
Lime, CaO	9.90
Magnesia, MgO	4.25
Sulfur trioxide, SO_3	10.36
Potassium oxide, K_2O	1.07
Sodium oxide, Na_2O	0.20
Undetermined	0.25
	100.00

Silica Value = 76.45
T250 = 2650 °F
Mercury =0.1 ppm

Charter Member

IOF:bvw

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO

I. O. Foster

Certified

COMMERCIAL TESTING & ENGINEERING CO.
GENERAL OFFICES: 228 NORTH LA SALLE STREET, CHICAGO, ILLINOIS 60601 • AREA CODE 312 726-8434

August 24, 1971

MAIL ADDRESS
16130 VAN DRUNEN ROAD
SOUTH HOLLAND, [illegible]
(CHICAGO, [illegible])
PHONE 312 [illegible]

NORTHERN TESTING LABORATORIES
P. O. Box 1561
Billings, Montana 54901

Sample Identification by
Northern Testing Laboratories

Sample No. A-6 18374-78

Kind of sample reported to us -----

Sample taken at -----

Sample taken by Northern Testing Laboratories

Date sampled ------

Analysis report no. 71-396529

MINERAL ANALYSIS

	IGNITED
Phos. pentoxide, P_2O_5	0.25
Silica, SiO_2	47.80
Ferric oxide, Fe_2O_3	4.50
Alumina, Al_2O_3	16.25
Titania, TiO_2	0.76
Lime, CaO	12.00
Magnesia, MgO	4.10
Sulfur trioxide, SO_3	11.96
Potassium oxide, K_2O	1.08
Sodium oxide, Na_2O	0.32
Undetermined	0.98
	100.00

Silica Value = 69.88
T250 = 2490 °F
Mercury, Hg = 0.2 ppm

Charter Member

IOF:bvw

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

I. O. Foster

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of: Coal Analysis Associated With Precipitator Tests

Date April 3, 1972
Job Number 64-53
Sheet 1 of 2

Report to: The Montana Power Company (1)
P. O. Box 1338
Butte, Montana 59701

ATTENTION: Mr. Dan Berube

Sample Identification:

On March 28, 1972, six (6) samples were delivered to our laboratory; we were directed to perform a proximate analysis on each, then combine the samples and perform an ultimate test on the combined samples.

TEST RESULTS:

PROXIMATE ANALYSIS

Lab No.	22626	22627
Mills	A-B-C	A-B-C
Load	86 MW	86
Run	A	A
Date	3-22	3-22
Time Start	11:55	12:45
Time Finish	12:42	1:32
% Moisture:		
As Received	10.2	10.8
Air Dry Loss	2.1	2.3
Oven Dry Loss	8.3	8.7
% Ash:		
As Received	10.2	9.9
Air Dry	10.4	10.1
Oven Dry	11.4	11.1
% Volatile:		
As Received	34.8	33.2
Air Dry	35.5	34.0
Oven Dry	38.7	37.2
% Fixed Carbon:		
As Received	44.7	46.1
Air Dry	45.7	47.2
Oven Dry	49.8	51.7
% Sulfur		
As Received	0.80	0.74
Air Dry	0.82	0.76
Oven Dry	0.89	0.83
BTU, per pound		
As Received	10,356	10,287
Air Dry	10,580	10,528
Oven Dry	11,536	11,528
BTU, per pound		
Ash, moist free	13,020	12,967

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

REVISED: April 12, 1972

Date April 10, 1972
Job Number 64-53
Sheet 1 of 1

Report of: Coal Analysis Associated with Precipitator Tests

Report to: The Montana Power Company (3)
P. O. Box 1338
Butte, Montana 59701
ATTENTION: Mr. Dan Berube

Sample Identification:

On April 4, 1972, six (6) samples were delivered to our laboratory; we were instructed to perform a proximate analysis on each.

TEST RESULTS:

PROXIMATE ANALYSIS

Lab No.	22708	22709*
Load	103	103
Test No.	2	2
Run No.	A	A
Date	4-3	4-3
Time Start	11:45	12:32
Time Finish	12:30	1:23
% Moisture:		
As Received	13.1	10.7-10.7
Air Dry Loss	4.7	2.8
Oven Dry Loss	8.8	8.1- 8.1
% Ash:		
As Received	10.0	10.2-10.5
Air Dry	10.5	10.5-10.8
Oven Dry	11.5	11.5-11.7
% Volatile:		
As Received	32.9	33.2-33.6
Air Dry	34.5	34.1-34.6
Oven Dry	37.8	37.2-37.7
% Fixed Carbon:		
As Received	44.0	45.6-45.2
Air Dry	46.2	47.0-46.5
Oven Dry	50.6	51.1-50.6
% Sulfur:		
As Received	0.74	0.75-0.75
Air Dry	0.78	0.77-0.76
Oven Dry	0.85	0.85-0.84
BTU, per pound:		
As Received	9,914	10,167-10,131
Air Dry	10,409	10,463-10,426
Oven Dry	11,407	11,383-11,350
BTU, per pound		
Ash, moist free	12,875	12,891-12,854

*Sample tested in duplicate

Certified

MC-110

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of: Coal Analysis Associated With
Precipitator Tests

Date April 12, 1972
Job Number 64-53
Sheet 1 of 1

Report to: The Montana Power Company (3)
P. O. Box 1338
Butte, Montana 59701
ATTENTION: Mr. Dan Berube

Sample Identification:

On April 7, 1972, six (6) coal samples were delivered to our laboratory with instructions to perform a proximate analysis on each.

TEST RESULTS:

Lab No.	22760	22761
Load No.	86	86
Test No.	3	3
Run No.	A	A
Date	4-6	4-6
Time Start	11:18	12:12
Time Finish	12:10	12:58
% Moisture:		
As Received	10.2	10.0
Air Dry Loss	2.5	1.8
Oven Dry Loss	7.9	8.3
% Ash:		
As Received	10.3	10.2
Air Dry	10.6	10.3
Oven Dry	11.5	11.3
% Volatile:		
As Received	34.2	34.2
Air Dry	35.7	34.8
Oven Dry	38.2	37.9
% Fixed Carbon:		
As Received	45.2	45.8
Air Dry	46.4	46.6
Oven Dry	50.3	50.8
% Sulfur:		
As Received	0.72	0.74
Air Dry	0.74	0.75
Oven Dry	0.80	0.82
BTU, per pound:		
As Received	10,355	10,373
Air Dry	10,625	10,567
Oven Dry	11,531	11,526
BTU, per pound:		
Ash, moist free	13,021	12,979

Certified

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Date April 19, 1972
Job Number 64-53
Sheet 1 of 2

Report of: Coal Analysis Associated With Precipitator Tests

Report to: The Montana Power Company (3)
P. O. Box 1338
Butte, Montana 59701
ATTENTION: Mr. Dan Berube

Sample Identification:

On April 13, 1972, nine (9) coal samples were delivered to our laboratory with instructions to perform a proximate analysis on each.

TEST RESULTS:

Lab No.	22798	22799	22800
Load No.	120	120	120
Test No.	4	4	4
Run No.	A	A	A
Date	4-11	4-11	4-11
Time Start	12:32	1:20	1:55
Time Stop	1:15	1:50	2:27
% Moisture			
As Received	8.7	8.9	8.8
Air Dry Loss	0.5	0.4	0.3
Oven Dry Loss	8.3	8.5	8.5
% Ash:			
As Received	10.9	10.7	10.5
Air Dry	11.0	10.7	10.6
Oven Dry	12.0	11.7	11.6
% Volatile:			
As Received	34.0	34.4	34.5
Air Dry	34.2	34.6	34.6
Oven Dry	37.2	37.8	37.9
% Fixed Carbon:			
As Received	46.3	46.1	46.0
Air Dry	46.6	46.2	46.2
Oven Dry	50.7	50.6	50.5
% Sulfur:			
As Received	0.78	0.78	0.79
Air Dry	0.78	0.78	0.79
Oven Dry	0.85	0.85	0.86
BTU, per pound:			
As Received	10,478	10,497	10,378
Air Dry	10,533	10,532	10,415
Oven Dry	11,482	11,514	11,398
BTU, per pound: Ash, moist free	13,033	13,040	12,887

continued...

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of: Coal Analysis Associated
With Precipitator Tests

Date April 25, 1972
Job Number 64-53
Sheet 1 of 3

Report to: The Montana Power Company (3)
P. O. Box 1338
Butte, Montana 59701
ATTENTION: Mr. Dan Berube

Sample Identification:

On April 18, 1972, eighteen (18) coal samples were delivered to our laboratory with instructions to perform a proximate analysis on each.

TEST RESULTS:

Lab No.	22986	22987	22988
Load No.	137	137	137
Test No.	5	5	5
Run	A	A	A
Date	4-13	4-13	4-13
Time Start	12:30	1:10	1:51
Time Stop	1:09	1:48	2:29
% Moisture:			
As Received	11.2	11.5	11.3
Air Dry Loss	1.4	0.8	0.7
Oven Dry Loss	10.0	10.9	10.7
% Ash:			
As Received	10.3	10.2	10.1
Air Dry	10.4	10.2	10.2
Oven Dry	11.6	11.5	11.4
% Volatile:			
As Received	33.7	33.8	33.9
Air Dry	34.2	34.1	34.1
Oven Dry	38.0	38.2	38.2
% Fixed Carbon:			
As Received	44.7	44.5	44.7
Air Dry	45.4	44.8	45.0
Oven Dry	50.4	50.3	50.4
% Sulfur:			
As Received	0.74	0.77	0.75
Air Dry	0.75	0.78	0.76
Oven Dry	0.83	0.88	0.85
BTU, per pound:			
As Received	10,147	10,158	10,197
Air Dry	10,292	10,238	10,266
Oven Dry	11,434	11,486	11,492
BTU, per pound:			
Ash, moist free	12,920	12,963	12,971

continued...

Coal Analysis Associated
With Precipitator Tests

April 25, 1972
Job No. 64-53
Sheet 2 of 3

The Montana Power Company
Butte, Montana
Attention: Mr. Dan Berube

Lab No.	22995	22996	22997
Load No.	86	86	86
Test No.	6	6	6
Run	A	A	A
Date	4-17	4-17	4-17
Time Start	10:25	11:05	11:45
Time Stop	11:04	11:45	12:35
% Moisture:			
As Received	9.3	9.5	10.0
Air Dry Loss	0.5	0.4	0.4
Oven Dry Loss	8.8	9.1	9.5
% Ash:			
As Received	10.7	10.6	10.5
Air Dry	10.8	10.6	10.6
Oven Dry	11.8	11.7	11.7
% Volatile:			
As Received	34.5	34.9	34.4
Air Dry	34.7	35.0	34.5
Oven Dry	38.1	38.6	38.1
% Fixed Carbon:			
As Received	45.4	45.1	45.2
Air Dry	45.7	45.2	45.4
Oven Dry	50.1	49.8	50.2
% Sulfur:			
As Received	0.88	0.89	0.88
Air Dry	0.88	0.89	0.88
Oven Dry	0.96	0.98	0.97
BTU, per pound:			
As Received	10,182	10,101	10,131
Air Dry	10,238	10,143	10,171
Oven Dry	11,229	11,159	11,239
BTU, per pound:			
Ash, moist free	12,732	12,638	12,714

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of: Coal Analysis Associated
With Precipitator Tests

Date April 27, 1972
Job Number 64-53
Sheet 1 of 2

Report to: The Montana Power Company (3)
P. O. Box 1338
Butte, Montana 59701
ATTENTION: Mr. Dan Berube

Sample Identification:

On April 20, 1972, nine (9) coal samples were delivered to our laboratory with instructions to perform a proximate analysis on each.

TEST RESULTS:

Lab No.	23007	23008	23009
Load	103	103	103
Test No.	7	7	7
Run No.	A	A	A
Date	4-19	4-19	4-19
Time Start	12:55	1:36	2:16
Time Stop	1:35	2:15	2:54
% Moisture			
As Received	8.9	8.4	8.4
Air Dry Loss	1.1	0.5	0.5
Oven Dry Loss	7.9	7.9	7.9
% Ash:			
As Received	10.7	10.5	10.7
Air Dry	10.8	10.6	10.7
Oven-Dry	11.8	11.5	11.6
% Volatile:			
As Received	33.9	34.3	34.9
Air Dry	34.2	34.5	35.1
Oven Dry	37.2	37.4	38.1
% Fixed Carbon:			
As Received	46.6	46.8	46.1
Air Dry	47.1	47.0	46.3
Oven Dry	51.1	51.1	50.3
% Sulfur:			
As Received	0.84	0.86	0.80
Air Dry	0.85	0.86	0.81
Oven Dry	0.92	0.93	0.88
BTU, per pound:			
As Received	10,302	10,498	10,488
Air Dry	10,415	10,555	10,541
Oven Dry	11,310	11,458	11,446
BTU, per pound:			
Ash, moist free	12,809	12,932	12,947

continued...

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of Coal Analysis Associated
With Precipitator Tests

Date April 28, 1972
Job Number 64-53
Sheet 1 of 2

Report to: The Montana Power Company (3)
P. O. Box 1338
Butte, Montana
ATTENTION: Mr. Dan Berube

Sample Identification :
On April 25, 1972, nine (9) coal samples were delivered to our laboratory with instructions to perform a proximate analysis on each.

TEST RESULTS :

Lab No.	23114	23115	23116
Load	69	69	69
Test No.	8	8	8
Run No.	A	A	A
Date	4-24-72	4-24-72	4-24-72
Time Start	10:15	10:55	11:36
Time Stop	10:54	11:35	12:15
Mill	ABC	AB	AB
% Moisture:			
As Rec'd.	13.3	13.5	13.4
Air Dry Loss	1.5	1.2	1.6
Oven Dry Loss	12.0	12.4	12.0
% Ash :			
As Rec'd.	9.8	9.8	10.0
Air Dry	10.0	9.9	10.2
Oven Dry	11.4	11.4	11.6
% Volatile :			
As Rec'd.	33.3	32.6	32.9
Air Dry	33.8	33.1	33.4
Oven Dry	38.4	37.8	38.0
% Fixed Carbon :			
As Rec'd.	43.5	44.1	43.7
Air Dry	44.2	44.6	44.4
Oven Dry	50.2	51.0	50.4
% Sulfur* :			
As Rec'd.	0.80	0.78	0.77
Air Dry	0.81	0.79	0.78
Oven Dry	0.92	0.90	0.89
BTU per lb. :			
As Rec'd	9958	10,093	9,866
Air Dry	10,111	10,219	10,028
Oven Dry	11,493	11,672	11,397
BTU per lb. Ash, moist free	12,957	13,159	12,878

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of: Coal Analysis Associated With Precipitator Tests

Date May 4, 1972
Job Number 64-53
Sheet 1 of 2

Report to: The Montana Power Company (3)
P. O. Box 1338
Butte, Montana 59701
ATTENTION: Mr. Dan Berube

Sample Identification:

On April 27, 1972, nine (9) coal samples were delivered to our laboratory with instructions to perform a proximate analysis on each.

TEST RESULTS:

Lab No.	23126	23127	23128
Load	103	103	103
Test No.	9	9	9
Run No.	A	A	A
Date	4-26	4-26	4-26
Time Start	10:00	10:41	11:20
Time Stop	10:40	11:19	12:00
Mill	ABCD	ABCD	ABCD
% Moisture:			
As Received	7.9	8.4	7.8
Air Dry Loss	0.6	0.6	0.4
Oven Dry Loss	7.3	7.9	7.4
% Ash:			
As received	10.5	10.2	10.3
Air Dry	10.6	10.2	10.3
Oven Dry	11.4	11.1	11.1
% Volatile:			
As Received	36.2	34.6	35.0
Air Dry	36.4	34.8	35.2
Oven Dry	39.3	37.8	38.0
% Fixed Carbon:			
As Received	45.4	46.8	46.9
Air Dry	45.6	47.1	47.1
Oven Dry	49.2	51.1	50.9
% Sulfur:			
As Received	0.80	0.76	0.82
Air Dry	0.81	0.77	0.82
Oven Dry	0.87	0.84	0.88
BTU, per pound:			
As Received	10,458	10,409	10,404
Air Dry	10,525	10,474	10,449
Oven Dry	11,352	11,368	11,289
BTU, per pound:			
Ash, moist free	12,812	12,787	12,698

continued...

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of: Coal Analysis Associated
With Precipitator Tests

Date May 5, 1972
Job Number 64-53
Sheet 1 of 2

Report to: The Montana Power Company (3)
P. O. Box 1338
Butte, Montana 59701
ATTENTION: Mr. Dan Berube

Sample Identification:

On April 29, 1972, nine (9) coal samples were delivered to our laboratory with instructions to perform a proximate analysis on each.

TEST RESULTS:

Lab No.	23186	23187	23188
Load	79	79	79
Test No.	10	10	10
Run No.	A	A	A
Date	4-28	4-28	4-28
Time Start	10:15	10:56	11:35
Time Stop	10:55	11:34	12:15
Mill	ABC	ABC	ABC
% Moisture:			
As Received	10.0	9.6	9.3
Air Dry Loss	1.8	1.2	0.4
Oven Dry Loss	8.2	8.5	8.9
% Ash:			
As Received	9.8	9.9	9.9
Air Dry	10.0	10.0	9.9
Oven Dry	11.0	11.0	10.9
% Volatile:			
As Received	34.6	34.6	35.0
Air Dry	35.2	35.1	35.1
Oven Dry	38.4	38.3	38.5
% Fixed Carbon:			
As Received	45.7	45.9	45.9
Air Dry	46.6	46.4	46.1
Oven Dry	50.7	50.7	50.6
% Sulfur:			
As Received	0.78	0.74	0.80
Air Dry	0.80	0.75	0.80
Oven Dry	0.88	0.82	0.88
BTU, per pound			
As Received	10,372	10,322	10,332
Air Dry	10,565	10,449	10,377
Oven Dry	11,516	11,416	11,391
BTU, per pound:			
Ash, moist free	12,932	12,812	12,785

continued...

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of: Coal Analysis Associated with
Precipitator Tests

Date May 8, 1972
Job Number 64-53
Sheet 1 of 2

Report to: The Montana Power Company (3)
Post Office Box 1338
Butte, Montana 59701
ATTENTION: Mr. Dan Berube

Sample Identification:

On May 1, 1972, nine (9) coal samples were delivered to our laboratory with instructions to perform a proximate analysis on each.

TEST RESULTS:

Lab No.	23239	23240	23241
Load	86	86	86
Test No.	11	11	11
Run No.	A	A	A
Date	4-30	4-30	4-30
Time Start	8:55	9:36	10:16
Time Stop	9:35	10:15	10:55
Mill	ABC	ABC	---
% Moisture:			
As Rec'd.	10.2	9.9	10.2
Air Dry Loss	1.0	0.6	0.8
Oven Dry Loss	9.3	9.4	9.5
% Ash:			
As Rec'd.	10.1	9.9	10.1
Air Dry	10.2	10.0	10.2
Oven Dry	11.3	11.0	11.3
% Volatile:			
As Rec'd.	34.3	34.0	34.6
Air Dry	34.6	34.3	34.9
Oven Dry	38.2	37.8	38.5
% Fixed Carbon			
As Rec'd.	45.4	46.0	45.0
Air Dry	45.9	46.3	45.4
Oven Dry	50.6	51.1	50.2
% Sulfur:			
As Rec'd.	0.73	0.74	0.75
Air Dry	0.74	0.75	0.76
Oven Dry	0.82	0.83	0.84
BTU per lb.			
As Rec'd.	10,198	10,452	10,528
Air Dry	10,297	10,513	10,614
Oven Dry	11,354	11,605	11,726
BTU per lb.			
Ash, moist free	12,786	13,039	13,204

continued...

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of: Coal Analysis Associated
With Precipitator Tests

Date May 9, 1972
Job Number 64-53
Sheet 1 of 2

Report to: The Montana Power Company (3)
P. O. Box 1338
Butte, Montana 59701
ATTENTION: Mr. Dan Berube

Sample Identification:

On May 3, 1972, nine (9) coal samples were delivered to our laboratory with instructions to perform a proximate analysis on each.

TEST RESULTS:

Lab No.	23253	23254	23255
Load	86	86	86
Test No.	12	12	12
Run No.	A	A	A
Date	5-2-72	5-2-72	5-2-72
Time Start	8:56	9:36	10:16
Time Stop	9:35	10:15	10:56
Mill	ABC	ABC	ABC
% Moisture:			
As Received	11.5	10.8	11.0
Air Dry Loss	3.0	1.6	1.7
Oven Dry Loss	8.3	9.3	9.5
% Ash:			
As Received	9.9	9.8	9.7
Air Dry	10.2	9.9	9.9
Oven Dry	11.2	11.0	10.9
% Volatile:			
As Received	33.4	34.1	34.8
Air Dry	34.4	34.7	35.4
Oven Dry	37.8	38.2	39.2
% Fixed Carbon:			
As Received	45.2	45.4	44.4
Air Dry	46.6	46.1	45.2
Oven Dry	51.1	50.8	50.0
% Sulfur:			
As Received	0.79	0.78	0.76
Air Dry	0.81	0.79	0.77
Oven Dry	0.89	0.87	0.85
BTU, per pound:			
As Received	9,935	10,198	10,217
Air Dry	10,238	10,366	10,390
Oven Dry	11,232	11,431	11,485
BTU, per pound:			
Ash, moist free	12,649	12,829	12,890

continued...

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of: Coal Analysis Associated
With Precipitator Tests

Date May 12, 1972
Job Number 64-53
Sheet 1 of 2

Report to: The Montana Power Company (3)
P. O. Box 1358
Butte, Montana 59701
ATTENTION: Mr. Dan Berube

Sample Identification:

On May 5, 1972, nine (9) coal samples were delivered to our laboratory with instructions to perform a proximate analysis on each.

TEST RESULTS:

Lab No.	23270	23271	23272
Load	79	79	79
Test No.	13	13	13
Run No.	A	A	A
Date	5-4-72	5-4-72	5-4-72
Time Start	9:12	9:53	10:33
Time Stop	9:52	10:32	11:12
Mill	ABC	ABC	ABC
% Moisture:			
As Received	8.9	8.5	8.4
Air Dry Loss	1.3	0.9	0.8
Oven Dry	7.7	7.7	7.6
% Ash:			
As Received	9.9	10.3	10.0
Air Dry	10.1	10.4	10.0
Oven Dry	10.9	11.2	10.9
% Volatile:			
As Received	35.3	35.1	35.1
Air Dry	35.8	35.4	35.4
Oven Dry	38.8	38.4	38.3
% Fixed Carbon:			
As Received	45.8	46.0	46.5
Air Dry	46.4	46.4	46.9
Oven Dry	50.3	50.3	50.8
% Sulfur:			
As Received	0.75	0.76	0.73
Air Dry	0.76	0.77	0.74
Oven Dry	0.82	0.83	0.80
BTU, per pound:			
As Received	10,210	10,319	10,305
Air Dry	10,344	10,412	10,385
Oven Dry	11,206	11,282	11,247
BTU, per pound:			
Ash, moist free	12,577	12,705	12,617

continued...

AREA X - ROSEBUD SEAM—
ULTIMATE COAL ANALYSIS
TEST HOLES 4 THRU 15

			AS RECEIVED							MOISTURE FREE						
HOLE NO.	SAMPLE DEPTH IN HOLE, FT.	COAL THICK., FT.	% CARBON	% HYDROGEN	% NITROGEN	% ASH	% SULFUR	% MOIS.	% OXYGEN	% CARBON	% HYDROGEN	% NITROGEN	% ASH	% SULFUR	% MOIS.	% OXYGEN
4.0	56.9 to 81.4	24.5	49.4	4.9	0.67	11.6	0.77	21.6	11.0	63.0	6.2	0.86	14.8	0.99	0	14.1
5.0	91.0 to 116.9	25.9	50.4	4.9	0.73	9.1	1.06	23.6	10.1	66.0	6.4	0.95	11.9	1.39	0	13.3
6.0	76.4 to 99.9	23.5	51.7	5.1	0.73	7.6	0.64	23.9	10.2	68.0	6.6	1.02	10.0	0.84	0	13.4
7.0	122.0 to 147.0	25.0	52.8	5.2	0.74	10.1	0.59	19.0	11.6	65.3	6.4	0.91	12.4	0.73	0	14.3
8.0	79.4 to 103.0	23.6	53.6	4.6	0.79	8.4	0.81	18.2	13.6	65.5	5.7	0.97	10.2	0.99	0	16.6
9.0	115.0 to 140.0	24.0	51.6	5.3	0.78	9.7	0.71	19.7	12.3	64.2	6.6	0.97	12.1	0.88	0	15.3
10.0	59.5 to 84.5	25.0	53.2	4.7	0.76	7.6	0.66	20.6	12.4	67.0	6.0	0.95	9.6	0.83	0	15.6
11.0	92.0 to 117.0	25.0	50.8	4.7	0.69	8.4	0.59	21.1	13.7	64.4	5.9	0.87	10.7	0.75	0	17.4
12.0	110.0 to 134.6	24.6	55.1	5.23	0.74	8.3	0.69	19.5	9.97	68.99	6.5	0.93	10.3	0.85	0	12.39
13.0	112.0 to 137.0	25.0	48.2	4.71	0.77	9.6	0.56	21.0	15.2	61.1	5.98	0.98	12.2	0.70	0	19.2
14.0	144.0 to 166.5	22.5	52.33	5.16	0.73	7.6	0.77	24.1	9.27	69.0	6.80	0.95	10.1	1.01	0	12.23
15.0	106.0 to 128.2	22.2	47.9	5.1	0.69	8.4	1.06	22.7	14.20	61.9	6.60	0.89	10.9	1.35	0	18.4
ARITHMETIC AVERAGE		24.23	51.419	4.967	.739	8.667	0.7425	21.25	11.962	65.356	6.323	.939	11.392	.943	0	15.18
STANDARD DEVIATION		3.05	2.093	.234	.038	1.157	.160	1.698	1.834	2.491	.348	.046	1.543	.214	0	2.22

Pg. 32

AREA R - ROSEBUD SEAM

PROXIMATE ANALYSIS (COAL)

TEST HOLES 4 THRU 15

			AS RECEIVED							MOISTURE FREE					
HOLE NO.	SAMPLE DEPTH IN HOLE, FT.	COAL THICK, FT.	% MOIST.	% VOLAT	% FIXED CARB.	% ASH	BTU	REC. SULF. %	LBS. SUL. MILLION BTU	% VOL.	% CARB.	% ASH	% SULF	BTU	M.A.F. BTU
4.0	56.9 to 81.4	24.5	21.6	31.8	35.0	11.6	8391	0.77	0.920	40.6	44.6	14.8	0.99	10,711	12,572
5.0	91.0 to 116.9	25.9	23.6	29.5	37.8	9.1	8759	1.06	1.209	38.6	49.5	11.9	1.39	11,453	13,034
6.0	76.4 to 99.9	23.5	23.9	29.9	39.0	7.6	8834	0.64	0.725	38.8	51.2	10.0	0.84	11,618	12,904
7.0	122.0 to 147.0	25.0	19.0	33.3	37.6	10.1	8811	0.59	0.669	41.1	46.5	12.4	0.73	10,873	12,418
8.0	79.4 to 103.0	23.6	18.2	33.6	39.8	8.4	8958	0.81	0.903	41.1	48.6	10.2	0.99	10,953	12,221
9.0	116.0 to 140.0	24.0	19.7	32.1	38.6	9.7	8811	0.71	0.806	39.9	48.1	13.6	0.85	10,969	12,695
10.0	59.5 to 84.5	25.0	20.6	32.8	39.9	7.5	8952	0.66	0.736	41.4	49.0	9.6	0.83	11,202	12,415
11.0	92.0 to 117.0	25.0	21.1	33.7	36.7	8.4	8800	0.59	0.680	42.8	46.5	10.7	0.75	11,004	12,323
12.0	110.0 to 134.6	24.6	19.5	30.0	42.3	8.3	9240	0.69	0.747	37.2	52.5	10.3	0.85	11,453	12,795
13.0	112.0 to 137.0	25.0	21.0	31.3	38.1	9.6	8534	0.56	0.656	39.7	48.2	12.2	0.70	10,864	12,231
14.0	144.0 to 166.5	22.5	24.1	27.5	40.7	7.6	8898	0.77	0.865	36.3	53.6	10.1	1.01	11,729	13,031
15.0	106.0 to 128.2	22.2	22.7	29.8	39.0	8.4	8686	1.06	1.220	35.6	50.5	10.9	1.35	11,235	12,611
ARITHMETIC AVERAGE		24.23	21.25	31.242	38.625	8.667	8800.33	.743	.845	39.675	49.067	11.392	.943	11121.4	12615.5
STANDARD DEVIATION		3.05	1.898	1.093	1.789	1.1571	210.67	.160	.186	1.787	2.486	1.543	.214	323.153	258.931
Range		22.2-25.9	18.2-24.1	27.5-33.7	35-42.3	7.6-11.6	8391-9240	0.56-1.06	0.669-1.22	36.3-42.8	44.6-53.6	9.6-14.8	0.70-1.39	10,711-11,729	12,221-13,034

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

REVISED: April 19, 1973
REVISED: April 18, 1973

Date March 9, 1973
Job Number 69-147
Sheet 1 of 2

Report of: Proximate Coal Analysis
Area E
N47 E63

Report to: Western Energy Company (2)
115 North Broadway
Billings, Montana 59101
ATTENTION: Mr. Roger Rice

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APR 24 1973
WESTERN ENERGY COMPA
GEOLOGICAL DEPT.

Sample Identification:

On October 30, 1972, coal samples were delivered to our laboratory with instructions to perform proximate coal analyses.

TEST RESULTS:

Drill Hole No. Depth, Feet Formation Lab No.	N47 E63 120.7-125.0 Rosebud 27215	N47 E63 125.0-130.0 Rosebud 27216	N47 E63 130.0-135.0 Rosebud 27217	N47 E63 135.0-139.5 Rosebud 27218	N47 E63 139.5-143.5 Rosebud 27219	N47 E63 120.7-14 Rosebud 27215-27 (composi
% Moisture:						
As Received	24.6	23.8	23.8	25.7	25.2	24.6
Air Dry, Loss	20.4	19.4	19.3	21.6	21.2	20.2
Oven Dry, Loss	5.2	5.5	5.6	5.3	5.1	5.4
% Ash:						
As Received	8.5	9.9	5.6	7.5	8.3	8.1
Air Dry	10.7	12.3	6.9	9.6	10.5	10.2
Oven Dry	11.3	12.9	7.4	10.2	11.1	10.8
% Volatile:						
As Received	28.6	27.4	29.1	27.4	28.1	28.5
Air Dry	35.9	34.0	36.1	35.0	35.7	35.7
Oven Dry	37.8	35.9	38.2	36.9	37.6	37.8
% Fixed Carbon:						
As Received	38.4	38.8	41.4	39.3	38.3	38.8
Air Dry	48.2	48.2	51.4	50.1	48.7	48.7
Oven Dry	50.9	51.0	54.4	52.9	51.3	51.5
% Sulfur:						
As Received	0.92	.79	.48	.36	1.8	.88
Air Dry	1.16	.98	.59	.47	2.33	1.11
Oven Dry	1.22	1.03	.62	.49	2.5	1.2
BTU per lb.						
As Received	8,322	8,376	8,837	8,213	8,109	8,388
Air Dry	10,457	10,387	10,956	10,475	10,297	10,525
Oven Dry	11,034	11,106	11,603	11,058	10,848	11,125
BTU per lb. Ash, moist free	12,301	12,736	12,530	12,315	12,203	12,471

continued...

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of: Proximate Coal Analysis
Area E
N42 E67

Date February 16, 1973
Job Number 69-147
Sheet 1 of 2

Report to: Western Energy Company (2)
113 North Broadway
Billings, Montana 59101
Attention: Mr. Roger Rice

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WESTERN ENERGY COMPANY
GEOLOGICAL DEPT.

Sample Identification:

On October 30, 1972, coal samples were delivered to our laboratory with instructions to perform proximate analysis.

TEST RESULTS:

Drill Hole No.	N42 E67	N42 E67	N42 E67	N42 E67	N42 E67	N42 E67	N42 E
Depth, Feet	101.7-106.7	106.7-111.7	111.7-116.7	116.7-119.7	119.7-123.7	123.7-127.2	101.7-
Formation	Rosebud	Rosebud	Rosebud	Rosebud	Rosebud	Rosebud	Rosel
Lab No.	26947	26948	26949	26950	26951	26952	26947-269 (composit
% Moisture:							
As Received	23.5	23.6	24.6	25.8	25.5	24.8	24.1
Air Dry Loss	12.7	12.2	19.5	19.6	20.6	20.2	17.2
Oven Dry Loss	12.3	13.0	6.3	7.6	6.3	5.8	8.3
% Ash:							
As Received	8.8	8.3	6.3	5.3	7.5	9.6	7.7
Air Dry	10.0	9.4	7.8	6.6	9.4	11.9	9.3
Oven Dry	11.5	10.8	8.3	7.2	10.0	12.7	10.1
% Volatile:							
As Received	28.9	29.6	29.2	28.2	28.7	27.3	28.6
Air Dry	33.1	33.7	36.3	35.2	36.2	34.3	34.5
Oven Dry	37.8	38.7	38.7	38.0	38.6	36.4	37.6
% Fixed Carbon							
As Received	38.9	38.6	39.9	40.7	38.2	38.3	39.6
Air Dry	44.6	43.9	49.7	50.7	48.1	48.0	47.9
Oven Dry	50.8	50.5	52.9	54.8	51.4	50.9	52.2
% Sulfur							
As Received	0.75	0.56	0.60	0.58	0.68	1.09	0.73
Air Dry	0.86	0.64	0.74	0.72	0.86	1.37	0.88
Oven Dry	0.98	0.74	0.79	0.78	0.92	1.45	0.96
BTU, per pound:							
As Received	8,839	8,654	8,767	8,602	8,792	8,406	8,697
Air Dry	10,127	9,853	10,896	10,705	11,075	10,535	10,506
Oven Dry	11,548	11,330	11,625	11,586	11,815	11,179	11,491
BTU, per pound:							
Ash, moist free	13,048	12,701	12,677	12,484	13,128	12,805	12,781

continued...

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of: Proximate Coal Analysis
Area E
N45 E66

Date January 29, 1973
Job Number 69-147
Sheet 1 of 2

Report to: Western Energy Company (2)
113 North Broadway
Billings, Montana 59101
ATTENTION: Mr. Roger Rice

Sample Identification:

On October 21, 1972, coal samples were delivered to our laboratory with instructions to perform proximate analyses.

TEST RESULTS:

Drill Hole No. Depth, Feet Formation Lab No.	N45 E66 111.0-116.0 Rosebud 26541	N45 E66 116.0-121.0 Rosebud 26542	N45 E66 121.0-126.0 Rosebud 26543	N45 E66 126.0-130.0 Rosebud 26544	N45 E66 130.0-135.0 Rosebud 26545	N45 E66 110.0-135. Rosebud 26541-2654 (composite
% Moisture:						
As Received	24.1	26.4	25.8	26.5	23.4	26.1
Air Dry Loss	18.1	18.9	19.2	21.6	18.9	19.2
Oven Dry Loss	7.3	9.2	8.2	6.3	5.5	8.6
% Ash:						
As Received	8.1	6.1	6.1	5.6	10.3	7.4
Air Dry	11.5	7.5	7.5	5.2	12.7	9.1
Oven Dry	12.4	8.3	8.2	7.6	13.5	10.0
% Volatile:						
As Received	31.0	26.6	27.9	28.9	29.4	28.9
Air Dry	37.9	35.2	34.6	36.9	36.2	35.8
Oven Dry	40.9	38.8	37.6	39.4	38.3	39.1
% Fixed Carbon:						
As Received	35.4	38.9	40.2	40.4	36.9	37.6
Air Dry	43.3	48.1	49.8	51.6	45.6	46.5
Oven Dry	46.7	52.9	54.2	55.0	48.2	50.9
% Sulfur:						
As Received	0.75	0.66	0.46	0.68	1.17	0.79
Air Dry	1.07	0.82	0.57	0.87	1.44	0.98
Oven Dry	1.15	0.90	0.62	0.93	1.52	1.07
BTU, per pound:						
As Received	8,454	8,611	8,800	8,706	8,457	8,582
Air Dry	10,322	10,619	10,890	11,111	10,435	10,622
Oven Dry	11,132	11,697	11,858	11,852	11,268	11,621
BTU, per pound:						
Ash, moist free	12,708	12,756	12,917	12,827	13,027	12,912

continued...

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Report of: Proximate Coal Analysis
Area E
N52 E61

Date December 19, 1972
Job Number 69-147
Sheet 1 of 2

Report to: Western Energy Company (2)
113 North Broadway
Billings, Montana 59101

Sample Identification:

On October 18, 1972, coal samples were delivered to our laboratory with instructions to perform proximate analyses.

TEST RESULTS:

Drill Hole No. Depth, Feet Formation Lab No.	N52 E61 80.0-85.0 Rosebud 26368	N52 E61 85.0-89.5 Rosebud 26369	N52 E61 89.5-93.5 Rosebud 26370	N52 E61 93.5-97.5 Rosebud 26371	N52 E61 97.5-101.5 Rosebud 26372
% Moisture:					
As Received	24.9	26.5	25.7	25.2	27.4
Air Dry Loss	19.2	21.7	20.3	19.2	16.8
Oven Dry Loss	7.1	6.1	6.8	7.5	12.7
% Ash:					
As Received	7.5	6.8	6.9	6.5	5.3
Air Dry	9.2	8.7	8.7	8.0	6.3
Oven Dry	9.9	9.2	9.4	8.7	7.3
% Volatile:					
As Received	29.3	29.3	29.1	29.3	28.9
Air Dry	36.2	37.4	36.5	36.3	34.8
Oven Dry	38.9	39.8	39.2	39.2	39.8
% Fixed Carbon:					
As Received	38.4	37.4	38.2	38.9	38.5
Air Dry	47.5	47.8	47.9	48.2	46.2
Oven Dry	51.1	50.9	51.5	52.1	52.9
% Sulfur:					
As Received	0.86	0.47	0.72	0.52	0.38
Air Dry	1.07	0.60	0.90	0.64	0.46
Oven Dry	1.15	0.64	0.97	0.69	0.52
BTU, per pound:					
As Received	8,858	8,675	8,695	8,778	8,750
Air Dry	10,960	11,084	10,913	10,860	10,519
Oven Dry	11,794	11,807	11,705	11,741	12,048
BUT, per pound:					
Ash, moist free	13,089	13,003	12,919	12,859	12,996

continued...

GREAT FALLS • MISSOULA • BILLINGS MONTANA • BOISE IDAHO

Revised : April 16, 1973

Report of: Proximate Coal Analysis
Area E
N49 E63

Date March 8, 1973
Job Number 69-147
Sheet 1 of 2

Report to: Western Energy Company (2)
113 North Broadway
Billings, Montana 59101
ATTENTION: Mr. Roger Rice

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WESTERN ENERGY COMPANY
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Sample Identification :

On November 14, 1972, coal samples were delivered to our laboratory with instructions to perform proximate coal analyses.

TEST RESULTS :

Drill Hole No. Depth, Feet Formation Lab No.	N49 E63 103.3-108.3 Rosebud 27175	N49 E63 108.3-112.3 Rosebud 27176	N49 E63 112.3-116.3 Rosebud 27177	N49 E63 116.3-120.3 Rosebud 27178	N49 E63 120.3-124.3 Rosebud 27179
% Moisture :					
As Received	25.9	26.5	24.9	26.5	25.4
Air Dry, Loss	19.4	20.1	16.9	20.2	18.5
Oven Dry, Loss	8.1	8.0	9.5	8.0	8.4
% Ash :					
As Received	6.3	7.9	7.1	6.0	8.6
Air Dry	7.9	9.9	8.5	7.5	10.6
Oven Dry	8.6	10.8	9.4	8.2	11.5
% Volatile :					
As Received	29.8	25.5	28.2	27.8	28.2
Air Dry	37.0	31.9	33.9	34.8	34.6
Oven Dry	40.2	34.7	37.5	37.8	37.8
% Fixed Carbon :					
As Received	37.9	40.0	37.9	39.7	37.8
Air Dry	47.0	50.2	48.1	49.7	46.4
Oven Dry	51.2	54.5	53.1	54.0	50.6
% Sulfur					
As Received	0.57	0.56	0.53	0.51	0.53
Air Dry	0.71	0.70	0.64	0.64	0.65
Oven Dry	0.77	0.76	0.71	0.70	0.71
BTU per lb.					
As Received	8,541	8,355	8,758	8,479	8,313
Air Dry	10,600	10,463	10,548	10,624	10,204
Oven Dry	11,536	11,371	11,656	11,542	11,144
BTU per lb. Ash, moist free	12,621	12,748	12,865	12,573	12,592

continued ....

Northern Testing Laboratories, Inc.

Proximate Coal Analysis
Area E
N49 E63

Revised: April 16, 1973
March 8, 1973
Job No. 69-147
Sheet 2 of 2

Western Energy Company
Billings, Montana 59101
Attention: Mr. Roger Rice

Drill Hole No.	N49 E63	N49 E63	N49 E63	N49 E63	N49 E63
Depth, Feet	124.3-127.6	103.3-127.6	146.2-151.7	151.7-155.9	146.2-155.9
Formation	Rosebud	Rosebud	McKay	McKay	McKay
Lab No.	27180	27175-27180 (composite)	27181	27182	27181-27182 (composite)
% Moisture					
As Received	23.7	25.4	26.7	27.4	27.1
Air Dry, Loss	19.4	19.0	22.1	22.7	22.4
Oven Dry, Loss	5.3	7.9	5.9	6.0	6.0
% Ash :					
As Received	12.6	8.2	9.4	5.3	7.2
Air Dry	15.7	10.1	12.1	6.9	9.2
Oven Dry	16.5	10.9	12.9	7.3	9.8
% Volatile :					
As Received	26.8	27.5	24.5	27.8	25.7
Air Dry	33.3	34.0	31.4	36.0	33.1
Oven Dry	35.2	36.9	33.4	36.0	35.2
% Fixed Carbon :					
As Received	36.8	38.9	39.4	39.3	40.2
Air Dry	45.7	47.9	50.6	50.9	51.7
Oven Dry	48.2	52.1	53.7	54.1	55.0
% Sulfur					
As Received	2.55	0.88	2.37	0.97	1.60
Air Dry	3.16	1.09	3.05	1.26	2.06
Oven Dry	3.34	1.18	3.24	1.34	2.19
BTU per lb.					
As Received	8,126	8,395	7,887	8,522	8,238
Air Dry	10,085	10,365	10,132	11,031	10,617
Oven Dry	10,647	11,247	10,762	10,724	11,290
BTU, per lb.					
Ash, moist free	12,751	12,623	12,355	12,647	12,516

Certified: ______________________

cc: Western Energy-Colstrip (1)
Western Energy-Butte (1)
Long Construction Co. (1)